GENERAL LIBRARY
NOV 1 1919
UNIV. OF MICH.

VOL. 6 NO. 3 SEPTEMBER, 1919

PROCEEDINGS 39TH YEAR

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

PUBLISHED IN MARCH, JUNE SEPTEMBER AND DECEMBER BY THE

AMERICAN WATER WORKS ASSOCIATION

AT 2419–21 GREENMOUNT AVE., BALTIMORE, MD.

SECRETARY'S OFFICE, 47 STATE ST., TROY, N. Y.

Subscription price, $5.00 per annum

Entered as second class matter April 10, 1914, at the Post Office at Baltimore, Md., under the act of August 24, 1912. Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 6, 1918

COPYRIGHT, 1919, BY THE AMERICAN WATER WORKS ASSOCIATION

R. D. WOOD & CO.

PHILADELPHIA, PA.

MANUFACTURERS

OF

MATHEWS FIRE HYDRANTS

Standard and High Pressure

CAST IRON PIPE

Bell and Spigot—Plain Ends—Flanged—High Pressure
Fittings of every description

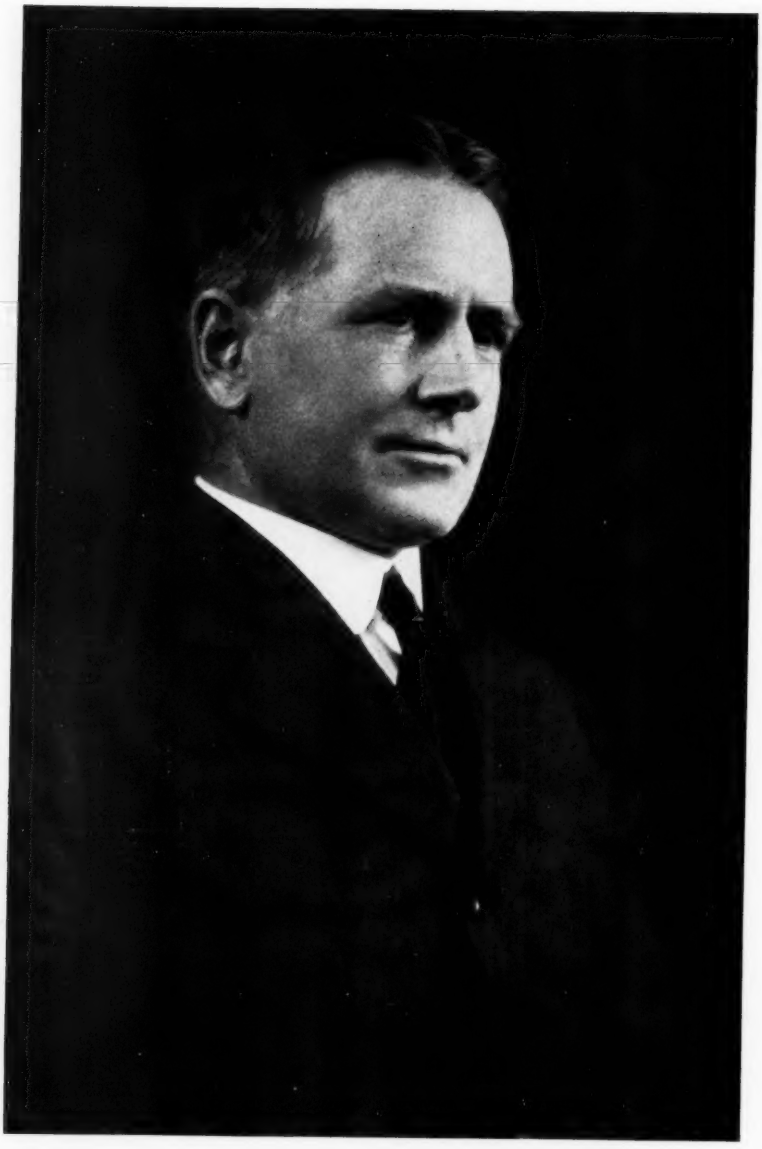
VALVES

Gate—Check—Foot—Indicator

PUMPS

Centrifugal Pumps—Hydraulic Pumps—Pumping Machinery

GAS WORKS MATERIAL



Carleton E. Davis, President 1919–1920

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings.

VOL. 6 SEPTEMBER, 1919 No. 3

COMMENTS

RESPONSIBILITY FOR DAMAGES CAUSED BY MAINS BROKEN BY INCREASED PRESSURES

The Appellate Division of the Supreme Court of New York rendered in May, 1919, an opinion in a case involving claim for damages due to the breaking of a water main after a higher pressure had been placed on the main by the introduction of Catskill water. The reasoning of the court is of interest to all water works men who have occasion to increase pressures on mains, and a brief outline of conditions will be given, together with the text of the opinion.

When the Catskill system was designed by the engineers of the Board of Water Supply the effect of high pressure on the old mains was considered, and it was decided that this question was one to be dealt with by the Department of Water Supply, Gas and Electricity, which has jurisdiction over the furnishing and delivering of water to the city. The engineers of this department examined the various designs and thickness of pipe used in the distribution systems of the five boroughs, and concluded that the system could safely stand a pressure of about 80 pounds per square inch. It was expected that numerous individual pipes would break when the increased pressure was turned on, but it was deemed impracticable to test the 200 miles of mains to be subjected to the higher pressure by isolating each section of pipe between valves and subjecting it to a hydrostatic test. The plan adopted was to turn on the higher pressure gradually and to repair any defects that developed. It was found that there was a number of lengths of mains that failed

under the higher Catskill pressure during the first year. The breaks were scattered throughout the boroughs of Manhattan and the Bronx, where the increase in pressure was most extensively made, the total number of breaks attributable to this cause being about 100. This is about double the normal number of breaks recorded in a year's time in these boroughs. After the first year the number of breaks has been no more than normal.

It is believed that the plan followed is the reasonable one under New York City conditions, but the decision of the court, if upheld by the Court of Appeals, shows that the city must bear all the cost of damages occasioned by a break in a water main on which the pressure has been raised without a preliminary test of strength. The opinion by Justice Bijur, in which all the judges concur, is as follows:

> Plaintiffs (executors of Kalman Haas) sue for damage caused in premises occupied by them by an inflow of water resulting from a break in a water main. The break succeeded the turning on of full pressure from the new Catskill aqueduct. It was shown that the pipes which burst had been laid some forty-seven years ago, at a time when the art of casting was not as well developed as at present; that such pipes undoubtedly corrode and grow weaker with use; that the city authorities were well aware that there was some danger of bursting as a result of the proposed increased pressure; that the pressure previously employed was 25 pounds to the square inch; that 10 additional pounds were first added; that the pipes thereupon broke in two localities in the neighborhood of plaintiffs' premises; that two weeks thereafter an additional 10 pounds pressure was introduced and that two days later the break occurred which is the subject matter of the present action.
>
> It is urged on behalf of the city that no causal connection was shown between the break in the pipes and the increased pressure. The question whether an effect complained of had been adequately traced to an actionable cause is necessarily one of degree and must be determined in each particular case according to all its circumstances. I think it suffices without rehearsing all the facts to say that the evidence is sufficient to convince a reasoning mind—perhaps even beyond a reasonable doubt—that the increased pressure caused the break.
>
> The city also contends that it is not chargeable with negligence under the general rule which accords to a municipality greater leeway in these matters than to an individual, and also because, as it claims, it was a fair inference from the testimony adduced at the trial that there was no feasible mode of testing the pipes before pressure was applied except by digging up all the city streets and testing every foot of pipe.
>
> The more liberal rule as to the city's vigilance and diligence has no application. Here no question of notice or knowledge is involved, it being apparent that all the facts were known to and the situation perfectly realized by the appropriate city authorities. Whether and to what extent typical

tests might have been made I do not think has been adequately developed at the trial, but assuming that the only perfectly reliable test would have been to examine all the pipes at a prodigious expense, the city cannot escape liability by voluntarily avoiding such expense and then practically making a more economical test at plaintiffs' cost. The method adopted amounted to a test in practice and the two breaks first referred to were a sufficient indication of what might and actually did thereafter follow. The second test in practice resulted in the break which caused the damage here complained of. I have no hesitation in holding that while the method adopted may have been on the whole a wise one from the standpoint of economy, the city cannot escape liability for its negligence by showing that the proper way of performing this work would have been more expensive.

W. W. BRUSH.

DAYTON'S EXPERIENCE IN MAKING COLLECTIONS

The collection of bills for water furnished by municipally owned plants is said to be lax at times. This was certainly the case in Dayton until two years ago. Consumers who failed to pay their bills by the fifteenth of the month were supposed to have a 10 per cent additional charge made against them. If a delinquent consumer offered this penalty it was received cheerfully and there was a place in the ledger for recording its receipt. If the consumer failed to tender the penalty, the face of the original bill was accepted for full payment. The rule was such a dead letter that a number of real estate operators made a practice of paying their water bills annually and not quarterly, and, it is hardly necessary to say, they did not pay in advance. One man operating over a hundred properties came into the office one day with a sheaf of bills from which he selected for payment only those carrying an overdue notice at the bottom. The water supply to the worst offenders was sometimes shut off, but that was about all that was done to enforce payments when long overdue.

The system was unfair to the consumer and recognized as a bad business condition which the management must remedy. Tenants left houses without paying their water bills and it was not always possible to collect them from the landlords. The losses from this cause and through the interest on overdue accounts was considered to be greater than the salary for a good assistant. It was accordingly decided to make a change and to attempt to collect bills promptly, even though nobody connected with the department had much confidence in the possibility of accomplishing a decided improvement. When the bills were sent out a notice accompanied them stating that the city had been wasting money through previous failure to insist

upon prompt payment of accounts and that this being the money of the citizens their coöperation in saving it was desired. On the sixteenth of the month the penalty was insisted upon, at first, and receipts were not given for payments made without it upon that or any later date. If the bill with penalty added was not paid by the twenty-fifth of the month the water was shut off. At first this was done without giving notice, in the belief that a notice would merely result in useless discussion, but experience showed that it was better to send a dunning statement on the sixteenth and to deliver by automobile on the twenty-fifth a notice that water would be shut off at the expiration of forty-eight hours if the account was not settled. A change in the financial arrangement was also made by which a discount of 5 per cent was allowed on bills paid on or before the fifteenth of the month and the penalty was reduced to 5 per cent and did not become payable until after the twenty-fifth. The minimum penalty after the water was shut off was fixed at one dollar. If the account was not settled within three days after the water was shut off the meter was removed and the account turned over to the legal department for collection.

Record of procedure in collecting water bills at Dayton, Ohio

MONTH	1917				1918				1919			
	16th, dun	25th, auto notification	27th, shut off	Meter out	16th, dun	25th, auto notification	27th, shut off	Meter out	16th, dun	25th, auto notification	27th, shut off	Meter out
January	634	165	29	10	483	278	77	39	670	160	27	19
February	434	210	35	13	449	200	53	28	427	142	35	12
March	839	223	43	10	398	278	54	13	732	332	32	10
April	676	219	56	16	624	185	28		710	245	48	14
May	529	137	31	5	534	175	39	15	558	162	31	14
June	666	291	39	10	736	264	57	17	976	243	32	5
July	664	206	43	13	741	215	52	20	849	234	50	14
August	624	154	36	13	456	206	61	30				
September	438	248	55	21	841	335	28					
October	620	203	72	23	674	291	43					
November	632	117	26	6	497	199	28					
December	603	213	40	26	868	225	46	16				
Total	7359	2386	505	166	7301	2761	566	*252	*8437	*2627	*455	*151

* Estimated.

The results of the experience in enforcing the payment of water bills in Dayton are shown in the accompanying table. The new system has eliminated all bad accounts. The last balance sheet showed three outstanding bills held for legal action and two for settlement by receivers. The system now meets with general favor. The discount is appreciated and the consumers are pleased because they know everybody gets exactly the same treatment. The results of the adoption of the system show that good business methods are popular and that a municipal department can make collections promptly if it chooses to do so.

H. C. WIGHT.

THE USE OF STATISTICAL DATA

Attention may profitably be directed to the paper by Mr. Wolman, in this issue of the JOURNAL, on the possibility of using index numbers to express the quality of water supplies. It is one of the few instances of the application of the science of statistics to the problems of water supply, and as that science can render great help to some of the technical branches of the business of supplying water it is regrettable that more attention has not been paid to it by water specialists. The misuse of technical statistical data is one of the most common errors seen today in technical papers. It is frequently the case that the results of investigations are tabulated in such a way that they mislead rather than instruct, and when the tabulated results are further altered by plotting their averages in diagrams the curves may convey impressions which are at wide variance with the actual facts.

The dangers of misuse can be illustrated by an example where they are generally appreciated. We are all familiar with diagrams which give the total rainfall for each month during a series of years. The rainfall for each month is indicated by a horizontal line and the diagram has the appearance of a succession of steps. There is no danger of improperly using this diagram, in all probability. But if any reader wishes to see how different the same data will appear in another grouping it is only necessary for the calendar months to be replaced by months beginning on the fifteenth day of each calendar month, or by weeks. Shortening the time interval, or the unit of measurement on the axis of abscissas, often introduces great irregularities into such diagrams. Such irregularities are not a matter of moment in water supply but they are vital in the disposal of storm water in our cities.

The relatively long-time periods of measurement employed by the water works designer must be replaced by the rainfall records in very short periods for the data to be of service to the designer of storm sewers. Such works based on any rational interpretation of monthly rainfall records would be found of inadequate capacity in most cases; the early combined sewers of Brooklyn afforded a convincing proof of this.

Another case of technical statistics was brought up at the last meeting of the Iowa Section by S. L. Etnyre, who urged that the American Water Works Association should take up the standardization of formulas for the velocity and loss of head in water mains. There are many such formulas in use today and numerous others which have been proposed but never came into use. Edward Wegmann has recently taken an active part in the development of one of them and Mr. Etnyre stated that he had worked one out. In each case they were based on tabulated data; in other words, they were problems in the interpretation of statistics.

Whether there is any call for the appointment of a committee to recommend a standard pipe formula is a matter for the members to determine; the Editor of the JOURNAL will be glad to receive their opinions on the subject, for the consideration of the Publication Committee. But if any thorough study of the subject is to be made, there are doubtless many users of pipe formulas who will be glad to have the proposed standard presented with the same class of data which accompany many similar statistical studies for the purpose of showing the range of accuracy of the formulas. In addition to the range of accuracy of the proposed formula as an average of the results of carefully and intelligently conducted pipe gaugings, there are also the very interesting questions concerning the effect of age and character of water on the capacity of mains, the influence of bends, reducers, gates and the like. From the viewpoint of a trained statistician, the problem is one which will occupy a committee several years before it can reach any useful conclusions, for much time must be spent in studying the experimental data and determining the weight to be given to each set of test results before it is possible to draw more definite conclusions from these data than have been deduced already by a number of students of the problem of the flow of water through pipes.

A. W. CUDDEBACK.

A BIT OF WATER WORKS HISTORY

In turning the leaves of the June JOURNAL, the writer noticed the words "Newark, Ohio," and for an instant questioned, "What about it? Is it up by Lake Erie? No; that is Norwalk." And then like a dream-film in the movies there is a vision of a crowded hall in a capital city, yes, Washington, and on the platform a grey-haired man, whose life had been devoted to water supply work, is speaking of Newark. In clear measured sentences he sets out a brief history. In 1885 the City of Newark having no water supply engaged an engineer of large experience who designed a water works, prepared specifications and advised the city in the matter of a franchise, as the city decided to build the works under a franchise contract. Particular attention was given to the terms under which the city should acquire the works at the end of a twenty-year period. That was Newark. And when the twenty years had passed Newark violated its agreements and built another identical plant, same general location, same source of supply, machinery, reservoirs of the same dimensions and site, another 16-inch force main and a new distribution system of thirty miles or more, robbing the investors to the utmost limit. That was in 1908. And that is the history that has been on the records of this Association, undenied and unquestioned for more than ten years. That is a test of accuracy.

And now in 1919 Newark comes up again through the industry of Mr. Dittoe, engineer of the Ohio State Board of Health. He found the city was crowding into its double-barrelled distribution system over four million gallons of water per day. Why? Because the manufacturers were stealing from the city mains about one-half of that quantity with as little regard for justice and mercy as the city itself had manifested in stealing from the original investors. Was a bunch of highwaymen ever satisfied with the first division of plunder from the mail coach? Were they not always ready to steal from each other? In Russia each takes whatever he can get—and the movement is called Bolshevism. In Newark each takes what he can get, but the Russian term cannot be fairly applied. In this country of freedom and equal rights no back-ground of oppression can be cited to excuse crimes. A new word of deeper meaning should be coined to define the activities of the citizens of Newark.

H. F. DUNHAM.

WHO'S WHO IN WASHINGTON

A large number of contractors, big and little, have just had an illuminating experience of a financial nature which deserves mention here because it shows clearly who's who in Washington, and why. It should be considered carefully by those inclined to believe that reorganization of Government bureaus will have any decided effect on the conduct of public affairs and will enable Government work to be done with the speed, economy and zest that mark well-managed private work.

When the United States entered upon the war an enormous construction program had to be started at once. A large part of this work dropped into the hands of what ultimately became the Construction Division of the army. At the outset that organization had the benefit of the counsel of the Committee on Emergency Construction of the Council of National Defense and its advisors, one of the most energetically helpful committees that functioned in Washington. Under its advice the Construction Division let a large number of contracts on the cost-plus basis, which was the only way to get things started while detailed plans were being prepared. The rush was so great, in fact, that the Marine Corps, which has a reputation for employing the minimum of red tape about anything it really wishes, turned both the engineering and construction of the Quantico camp over to one of the big general contracting companies, on the principle that where speed is vital it pays to concentrate the responsibility for results.

The cost-plus contracts referred to contained clauses requiring the contractor to file a bond with satisfactory sureties and allowing the premiums on these bonds to be classed among the expenses of the work for which the contractor should be reimbursed. Many contractors did receive pay for these premiums. Finally the law officers of the Treasury Department came to the study of such a provision, as they eventually come to a study of the legality of all expenditures of the Government bureaus, and notified the Controller of the Treasury that he must not reimburse the contractors who worked under such cost-plus contracts for the premiums they paid for bonds. The Controller may or may not stick to this advice, although he has been doing so up to the time of writing, but the incident is mentioned as showing in a perfectly clear way that there can be no real efficiency and power in a Government bureau so long as its own legal advisors

have only a preliminary power of authority over the financial administration of the bureau's affairs, and everything must be on tenterhooks until the unknown, overlooked but all-powerful supervisory staff of the Controller of the Treasury is at last able to settle matters.

As a matter of fact, the actual financial powers of Government bureaus in handling new work are almost a joke until the law clerks in the Treasury Department tell them what they can and cannot do. This is the reason that great enterprises authorized by Congress start into real action so slowly and there are such vexatious delays in securing any action of a novel nature. The heads of the bureaus do not like to acknowledge that they are not the heads of them, in a financial sense, but as a matter of fact until the men working in the Controller's office say what can and can not be done with money appropriated by Congress for any novel purpose these bureau chiefs must move very slowly. The real power in Washington lies with the men in the Controller's office; they are underpaid, there are not enough of them, and their responsibilities are enormous, yet it is only occasionally that they make a mistake, as will probably be found to be the case in this matter of premiums on contractors' bonds, which brings to the attention of the public the control they have over nearly every penny spent by the Government.

JOHN M. GOODELL.

COST ACCOUNTING

"Cost keeping in 1918 did not amount to much," according to the statement made in Mr. Judd's paper in this number of the JOURNAL, "so far as any comparative value of the records is concerned." A careful reading of that brief but useful paper will indicate that the records in question, if examined in detail, would show one very significant fact, namely, that a considerable part of the excessive cost of pipe-laying during the war was not due so much to the high wages of labor as to its very low efficiency. This feature of construction work is one which can be determined only by good cost keeping. Such cost keeping involves a great deal more, however, than a mere record that it took certain men a given number of days to lay a pipe of stated diameter a given distance in soil or rock which is described. It will be seen that Mr. Judd keeps a record of the weather, and anybody familiar with weather in Iowa knows that it has a material effect on the cost of construction. He keeps a record of the nature

of the trench, which also has a material effect on costs. There are other records which ought to be kept in order to enable the superintendent to check up the performance of a gang today with what a similar gang did in previous years.

The men in charge of construction work are facing the fact that not only are their records of costs in the past likely to be greatly exceeded by the cost of work done hereafter, but those records are in too many cases so incomplete that it is not possible to tell from them whether a good showing on a particular job was due to a good foreman, or to energetic experienced men in the gang, or to any other cause. The superintendent knows that he cannot get so much work from labor as he formerly did, dollar for dollar, and he is consequently giving more attention to labor-saving equipment. Such equipment will undoubtedly be useful in many cases, but one of the most useful things in the successful prosecution of construction work will be a cost keeping system which will show what different parts of the work are costing in such a clear and accurate way that possibilities of making savings can be studied without resorting to guess work. We are all facing the same problem, how to accomplish the best that is in us and how to help those working with us to accomplish the best of which they are capable, that the period of national readjustment may be as brief as possible. We cannot tell that we are living up to this aim without a system of records which will enable us to see what is really going on. The average man can learn what such records are worth by keeping account for a few days of what he does with his time. It is not difficult but the result, when examined some quiet evening, is likely to be a shock and a spur to better performance.

W. W. Brush.

ENGINEERS IN BUSINESS

At the present time the compensation received by civil engineers is so small, owing to the reduced purchasing power of the dollar, that the modest salaries formerly paid to them are wholly inadequate for the standard of living to which they are entitled as a result of the expensive education and long training needed to fit them for places of responsibility. As a result there is a general tendency for engineers to turn their attention to commercial and administrative pursuits. There is a considerable demand for engineers at the old rates

of compensation and for skilled draftsmen and designers. Such work is still attractive to those who like engineering, but the compensation for it is not considered adequate and accordingly the alleged greater opportunities in business pursuits are being investigated. As a necessary consequence of this, the technical schools, which see the handwriting on the walls, are abandoning their former claim that a course in engineering fits a man for about anything except the law, medicine and the pulpit, and are seriously contemplating developing courses in business engineering, engineering business, or any other name that can be thought of which sounds attractive.

A very large part of the engineers who graduate from a technical school and achieve success never have occasion to use more than a small part of the subjects they were taught to consider absolutely necessary for any engineer to master. They generally spent four years in a high school or academy and then four years in a technical school in order to fit themselves for their engineering career. They were told that they could not be fitted in less time. They compare their experience with that of their boyhood friends of equal ability who went part way, or all the way, through high school and then entered business, and find that most of these business men are earning more money than they are. They feel that this is wrong, that their expensive education and great responsibilities merit at least equal compensation, but they forget two things, first, that the information they are really using could have been acquired in less than eight years and, second, that there is no difficulty in filling their places when they resign, without any increase in compensation. They also overlook the fact that there is a plain indication of the value of the ordinary business man, namely, the profits which he can show he has made for his employer, whereas up to date there is no indication of the profits which a competent engineer can show because his work is that of a spender in most cases.

There was a conference in Washington in June at which a large number of educators of engineers discussed the means of supplying the demand for men of engineering knowledge and business training. There is no greater demand for such men now than there was during a period of several years before the United States entered the war. More engineers are looking for such places, however, and they are talking so much about it that there is a misconception of the real situation. Employers of salesmen for whom engineering knowledge is useful are not looking, as a rule, for men whose engineering knowl-

edge has been acquired solely in schools; they desire men who have had field experience and who are salesmen by temperament. Now the qualifications for successful salesmanship and successful business administration are not the same as those for successful engineering practice, unless the last term is stretched to include the administrative responsibilities which the engineering heads of some organizations must possess in order to discharge their duties successfully. Consequently the attempt to graft on to a course in engineering a course in economics and one in salesmanship is an educational problem of the highest complexity, unless it is assumed that the student has the time and money to spend more than four years at his special studies.

As a matter of fact, there are many excellent opportunities for engineers in business, but rarely as engineers and this fact they should not forget. One of the leading authorities on a special branch of mechanical engineering never speaks of himself as an engineer, although every week his engineering advice is sought and followed by eminent engineers, but invariably designates himself as a salesman. Every assistant he has is not only a technical graduate but also an engineer of some practical experience, yet every one of them is definitely instructed not to claim to be an engineer but to call himself a salesman. A similar policy is followed by some of the largest manufacturers of electrical equipment, which maintain engineering organizations to give technical advice to customers but forbid these men to discuss sales, which are handled exclusively by other men of engineering experience and generally of technical education but known as sales representatives solely. In short, if an engineer goes into business or into administrative work he must step out of his position of engineering authority, and the trouble with engineers in such places has been that they endeavor to control the details of engineering matters under them and neglect the business and administrative problems which are their special province.

There is no administrative field in which engineering knowledge is of more value than in the management of public utilities. Many of the best known managers today have been drawn from engineering circles. That is, perhaps, not the best method of stating the facts; these men have usually asked to be transferred from the engineering to the administrative departments. They were able to show that they had qualifications which warranted giving them a trial and they made good. Engineering knowledge in itself is not a qualification

for administrative positions; it is merely a useful accomplishment, so to speak. So in all these discussions of engineering salesmen and engineering administrators and methods of turning them out of technical schools by changing a few of the subjects taught, the fact is not recognized that a salesman or an executive deals with men and not with the direction of the forces of nature to the good of mankind, and, up to date, there is not a single subject in engineering courses which throws light on why one man has influence and another has none. Both salesmanship and administrative work call for forceful personality, and an engineer who has it and is dissatisfied with his engineering position can look about for change of pursuits with some hope of winning success. But the engineer who does not have a forceful personality but is a good engineer, will do better to stay in engineering.

JOHN M. GOODELL.

THE ADMINISTRATION OF THE PUBLIC WORKS OF BUFFALO[1]

By A. W. Kreinheder

It is a privilege to come here this morning and on behalf of the mayor and the council of the city, as well as 525,000 Buffalonians, to extend to you a hearty welcome of our city. We are proud of our city, just as proud as you are of yours. Among our industries we have some large institutions that have made Buffalo famous, such as the Pierce-Arrow Motor Car Company, the Lackawanna Steel Company, and a great many other institutions just as large. In addition to that, Buffalo is the greatest grain port in the world. We have an elevator here with a capacity of over 4,000,000 bushels of wheat, and other big plants along the same line.

Buffalonians are also justly proud of the fact that the business of this city is being conducted under an excellent form of commission government which has been in existence since January 1, 1916. All the business of this city, the power to do its business, is vested in five men who are charged with the responsibility of carrying out their duties in accordance with the designation of the council.

The five heads composing the government of the city are as follows: the mayor, who has general oversight and heads the department of public safety, which takes in the police, fire and health activities; the commissioner of finance and accounts, who has charge of the assessment department, the comptroller's department, the auditing department, and the treasury department; the commissioner of parks and public buildings, who looks after our beautiful parks and public buildings, and sees that buildings are erected in accordance with building ordinances of the city; the commissioner of public affairs, who looks after the welfare work of our city, and questions relating to the public utilities; the commissioner of public works, who has charge of the bureaus of engineering, water and streets.

[1] Extract from the address of welcome to the Buffalo Convention, June 10, 1919. The author is Commissioner of Public Works of Buffalo.

The mayor has no veto power. Three votes constitute a majority vote, and are sufficient to pass on any proposition not involving the expenditure of money. The latter calls for a four-fifths vote.

All of the city's business is done by communication directly from the various department heads to the council, so that each department's records must be absolutely complete in detail, and its communications must be such that taxpayers can clearly understand the subject matter. The city's business is done publicly all the time. There are no secret sessions behind closed doors. That is the way a city's business should be transacted.

I said that the commissioner of finance and accounts has charge of the assessable property. While we are on that, I wish to emphasize this, that if the commission form of government has done nothing else it has done one big thing at least, and that is that the property in the City of Buffalo today is assessed equitably; in other words, it is equalized. You will no longer find on the assessor's books a piece of property that is worth $45,000 or $50,000 assessed on the basis of $7,500. You will not find any more such things as a piece of property that is worth $4,000 being on the books for $400. There are no more such things as railroad property being assessed at 3 cents a foot when it should be 85 cents. Every man today gets a square deal in the City of Buffalo, and if he believes that his rights have been transgressed, his remedy is the council who at all times will give him a hearing no matter who he may be.

I hope that the local entertainment committee has arranged to take you through our beautiful parks and to show you that beautiful meadow, which they tell me is one of the largest and finest meadows in this country. We no longer have signs staring you in the face along all of our parkways, "Keep off of the Grass," but on the contrary, Park Commissioner Malone has opened up the parks for recreation purposes, so that today our parks contain golf links, lawn tennis courts, base ball diamonds and everything else for recreational purposes for the enjoyment of the people of the city.

With reference to the department of public affairs, the commissioner of that department looks after the welfare work of our city hospitals and institutions of that kind. Every facility is afforded the people of Buffalo in the way of protection against tuberculosis and other diseases. If there are families that are in need, necessary aid is given them.

Then there is the department of public works, over which I have had the honor to preside since January 1, 1916. In 1915, with only twenty-four hours consideration, I consented to run for commissioner under this commission form of government, which I am thoroughly convinced is the best method to handle a city's business. It would have been impossible for me, had I been hampered under a political system, to do the things that have been done in the department. I have had the able aid of the men who head the various bureaus. In the department of public works we have three bureaus, the bureau of streets, the bureau of engineering, and the bureau of water. The bureau of streets looks after the collection of all ashes, refuse, etc., looks after the cleaning of the streets and all of the lighting of our public highways and streets, and also after sign licenses, etc. When I say to you that the price of flushing our streets has been reduced to approximately 20 cents a great square, instead of $1.45 under the old method, that will give you an inkling of the savings that have been effected in that department. The bureau of streets is headed by William F. Schwartz.

The bureau of engineering is headed by Captain George H. Norton, an able engineer, who looks after street construction and repairs, the laying of all walks, the building of all sewers, the building of drains, viaducts, the dredging of our river, the preservation of our bridges and the construction of new bridges, etc.

The bureau of water, as you know, is headed by George C. Andrews, who has charge of the entire work of that department. It has been a pleasure to me to observe what the saving has been in that department, even without metering water except that used for commercial purposes. While Buffalo formerly had a daily consumption of 339 gallons per capita, we have today brought that down to 240 gallons per capita, by the installation of meters where water is used for other than domestic purposes, and by making a pitometer survey and thus detecting leaks in our mains and services. Where our pumpage was formerly 177,000,000 gallons per day, it is now 120,000,000 gallons per day. I think that is a record that the head of that bureau may well be proud of and which I do not believe is excelled in any city.

We are proud of our city's financial condition. We have today an assessed valuation in the City of Buffalo of approximately $575,000,000. The city cannot bond itself for more than 10 per cent thereof, or $57,500,000. Our outstanding bonds today, that is

prior to the latter part of May, amounted to $25,000,000; but we did issue $4,765,000 worth of bonds two weeks after the Fifth Liberty Loan closed, and got a premium of $66,000, so that the bonds were sold at about 4¼. Now then, what is this money for? This money is for the purpose of helping our national government and the American people. The war has been closed, and we are glad of it. The boys have ended their fight over there and all glory to them; but the reconstruction period is here and it is up to us, it is up to every state, every municipality, town and village, and it is up to this and all other organizations to do all in their power to assist the Federal govern ment to bring about normal conditions as quickly as we can. To this end, what did Buffalo do? In the month of January a communication came from the board of education which, after several hearings, was immediately adopted by the council and calls for the erection of twelve intermediate schools, eight grammar schools, and additions to the LaFayette High School, at a cost of $8,000,000. Of this amount $3,000,000 will be expended on the purchase of the necessary sites, the other $5,000,000 will be spent for buildings, labor and material. A bond issue of $4,600,000 has been ordered which will carry out the work which has been started up to November 1 when the next bond issue is to be $2,600,000, to be expended in improvements to our public schools alone. Besides all of our construction and reconstruction in the City of Buffalo, we have just recently let a contract to Graham and Henderson of Cleveland, Ohio, who are to build a storm-water drain at a cost of $347,000. Harrison P. Eddy is just now approving our plans for the building of a big drain through the city, replacing an old creek, which will cost at least $2,000,000. That is one illustration to prove to you that Buffalo is not lacking in public spirit and patriotism but seeks to provide for the unemployed and will assist the government in every way possible so as to give employment for returning soldiers.

Now what else is the city doing for the returned soldiers? All of our boys who have been in the service of the city, who either enlisted or were drafted into the service of the government, have received the difference in pay between what the government paid them and what their pay in the military service was, and that applies to every man who was working for the city, no matter what his position was. That applies to the man who was getting a salary of $3,000 a year and was drafted and paid $30 a month, or whatever his pay was. I was interested the other day in the case of a city driver who enlisted

in 1917 and who lately walked into a city office and said: "Gentlemen, I am entitled to the difference in my pay between that paid me by the government and the city. I have been honorably discharged from the United States government service." We knew who he was and that he had been in the employ of the city four years prior to that time. That man was paid a difference of $993. The bureau of streets will pay out $28,000 in that way alone, and the cost to the entire city will undoubtedly amount to about half a million dollars.

REDUCTION OF WATER CONSUMPTION BY MEANS OF PITOMETER SURVEY AND CONSTANT INSPECTION[1]

By George C. Andrews

In 1897 the Buffalo Common Council decided it more advantageous to its citizens to install more pumps and give practically an unlimited supply of water than to control consumption by means of meters. It is hardly necessary to add that this decision was made contrary to sound engineering advice. "Free water" is a slogan that often appeals to the unthinking. It would be interesting to speculate on what that decision has cost the citizens of Buffalo in the past twenty-two years. Suffice it to say that in 1903 the Bureau of Water had a bonded debt of $3,699,382.00, while it was $12,141,524.00 in 1917. From that date until 1917 it was a race between the unchecked waste in both mains and houses and the pumps.

In 1903 there was one pumping station with a daily capacity of 183,000,000 gallons. In 1917 there were two pumping stations with a combined daily capacity of 330,000,000 gallons. Coincident with the increased pumping capacity large distributing mains were laid. During this period the per capita consumption had ranged between 302 and 339 gallons per day. Of this practically 100 gallons was for industrial use.

In 1916 the city government was altered and a commission of five men elected to govern the city. Their platform was an economical and efficient city government, and one of the early efforts was an investigation as to means to reduce the city water consumption. As all water used must be pumped from Lake Erie against a head of 140 to 204 feet, a reduction in pumpage would make an immense saving in coal used for fuel. Various methods were considered and in the Spring of 1917 it was decided to have a pitometer survey made of a small section of the city with the idea of covering the whole city later should this section show satis-

[1] Read before the Buffalo convention June 10, 1919.

factory results. The question of metering was considered, but rejected on various grounds, some of which were the popular local prejudice against metering, the length of the time to meter the city completely, there being over 76,000 ummetered and active services, extensive changes in plumbing required in many of the poorer types of dwellings should meters be installed, and the heavy initial investment required for meters, while the pitometer method promised early results.

Figure 1 shows by months graphically the rapidly increasing yearly consumption from 1913 to 1917. Table 1 gives some statistics which supplement the information in the diagram.

To facilitate the work and also that definite records could be obtained of water consumption in different points, the city was

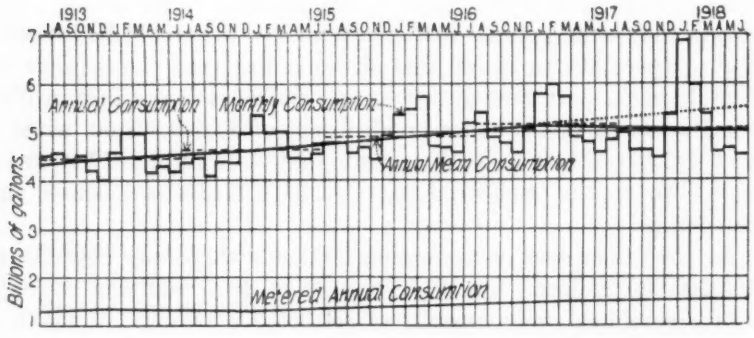


FIG. 1. MONTHLY CONSUMPTION OF WATER, 1913–1918 (SEE TABLE 1)

divided into ten sections, no two of which were similar in character, and the work completed by sections.

Section 1 included manufacturing use, poor, good, and high grade residential districts.

Section 2 is an old residential section with most of the buildings antedating the modern sewer and water service. In this section the toilets are usually of the so-called anti-freezing type installed in a shed in the rear of the house. The waste in this section was tremendous.

Section 3 is a portion of the city sub-divided in the nineties when water mains, sewers and services were laid. This section is only now being developed. The residences built are of fair construction. In this section the rock lies close to the surface and in many streets

water mains and house services are laid in the sewer trench. The value of the pitometer was proven in this section, as ever-leaking unfinished supplies which were discharging into the sewers were discovered and stopped. Along Fillmore Avenue quarries had been opened years ago and water from a broken 16-inch main discharging into the face of the pit had for years furnished excellent water for men and teams working in the quarry.

Section 4 is principally high class residential, such as the Delaware Park section. The western portion, however, has heavy manufacturing use of water and poor class dwellings. Three-fourths of this section is built on rock strata close to the surface.

Section 5 is high class residential, principally, with the eastern portion of middle-class dwellings. No manufacturing use of water.

TABLE 1

Water used and wasted in Buffalo from July, 1913, to June, 1919, inclusive

PERIOD	ANNUAL PUMPAGE	QUANTITY METERED	QUANTITY USED BY FLAT-RATE CONSUMERS, OR WASTED
	gallons	*gallons*	*gallons*
July, 1913, to June, 1914.....	53,330,674,000	16,176,835,000	37,153,839,000
July, 1914, to June, 1915.....	55,262,784,000	15,548,187,000	39,714,597,000
July, 1915, to June, 1916.....	58,514,254,240	16,666,042,000	41,848,212,240
July, 1916, to June, 1917.....	61,490,593,540	17,722,530,000	43,768,063,540
July, 1917, to June, 1918.....	61,017,090,980	18,019,927,500	42,997,163,480
July, 1918, to June, 1919.....	49,482,000,000	18,243,000,000	31,239,000,000

Section 6 takes in the heart of the business section of the city. The northern portion is composed of middle class dwellings, but 80 per cent of the water is used commercially.

Section 7 contains poorer class dwellings and has a large manufacturing use of water. All the big packing-houses and stockyards are included in this section.

Section 8 includes most of the water front of the city, with large manufacturing plants and commercial use of water. It has a poor class of dwellings, and is the oldest section of the city.

Sections 9 and 10 have middle class dwellings, with some large steel mills on the outskirts. Railroad yards are large consumers in these sections.

The theory of a pitometer survey may be briefly described as follows: A certain section of the mains is isolated by closing all but one of the boundary valves. A special corporation cock is inserted

on the main feeding this district through the open valve. The main is traversed and the velocity of the water determined by the instrument inserted in the main through the corporation cock. Gaugings are recorded on sensitive paper for forty-eight hours and from the velocities shown the flow computed. As all the water entering this section passes the instrument the amount measured must be the supply to the district. The interesting or indicating feature of these records is the relation between the minimum night rate, which is usually found between 12.00 and 3.00 a.m., and the total twenty-four hour consumption. A high night rate, unless accounted for industrially, means leaky fixtures or breaks in mains.

As the isolation of a section is apt to leave some industries just within and without the district short on water pressure, causing complaints of low pressure, a map is kept in the office of the Superintendent of Maintenance on which all valves closed are indicated by a red-headed pin. By this means one can at a glance determine if a complaint of lack of pressure is due to the pitometer work or to some other cause. These pins for closed valves are corrected each morning.

After the total measure of a district is made, sub-division work is started. Sub-division is the determination of the consumption block by block, and is always done at night. The pitometer is set at the gauging point and the district shut off block by block, the time of each shut-off being noted. By comparing the time with the consumption shown on the photo-chart at the corresponding time, the rate for each block can be determined. This is a very important feature of the pitometer work, as by comparing the consumption for the different blocks one knows immediately where the inspection of fixtures will give the greatest result. It is an especially valuable feature for the control of the house waste after a survey has once been made. By means of the pitometer and proper sub-division, house to house inspections can give results twice as quickly as though no pitometer were used, as efforts will be confined to blocks where the sub-division indicates the greatest results are to be obtained.

Immediately after the sub-division work was completed, inspectors were placed in the district and house to house inspection made.

To make the survey, an engineer in charge and four assistants were employed. Three trucks with gangs of four were constantly engaged and one clerk assigned to this work to keep the records. Twelve of the regular city inspectors made the house to house inspec-

tions. Later, as more of the city was covered, twenty temporary inspectors were engaged.

One of the assistant engineers made the district measurements, and two were constantly engaged on sub-division. One assistant engineer tested the meters and fire lines. During the winter months two men worked in the office.

The inspection for house waste is of great value, and a large percentage of the total waste eliminated is directly due to inspection. However, proper control must be exercised or the results will be indifferent.

From 1906 until 1915, the department employed men to stop house waste, but had no control over them by means of district measurements. During this period the per capita consumption was practically stationary, although the annual consumption increased.

As the sub-divisions showed waste in practically every block, a system of inspection records was developed. Inspectors worked in pairs and a report on every house and service made. Where leaks were discovered, a repair notice was left. Two weeks later a second inspection was made of all places where notice to repair was served. If repairs had not been made at that time, a second repair notice was left and a re-inspection made three days later, at which time water was turned off unless all plumbing was in good shape. The years of unlimited use and waste of water had rendered most people indifferent to the condition of the plumbing in their houses and at first considerable complaints were made at the so-called arbitrary ruling of the Bureau. However, these soon ceased as the results of the survey became apparent and in the majority of cases splendid co-operation was secured.

The inspectors tested first the house fixtures, and then if these were all right, tested with the aquaphone at the curb-box for service leaks. If house waste was found, the stop-cock at the house was closed before testing for service leaks. On their inspection report blanks, leaks were listed as service, faucet, toilet, etc., and a notice showing the nature of the leak served. A record of the number of people on each service was also reported. After the house inspection in a district was completed, the pitometer was again used to record the flow in different blocks in the sub-division. Where the night rate was still excessive, investigation for underground leaks was started. The determination of underground leaks is

largely a matter of skill, judgment and experience. By sub-dividing by blocks the leak can be located as to the block, but then the operator must find it by skill and judgment. If service pipes and boxes have been installed the aquaphone can give one the approximate location, and by driving a steel rod to the main the leak can be closely located. In only a few cases was it necessary to excavate more than one hole to find the leak.

Probably the most difficult work in this line was on Northland Avenue, in Section 3, where a night rate of 755,000 gallons was shown on one block. As there were practically no houses, and only one factory, which was metered and did not account for but a fraction of the flow, all indications pointed to a large joint leak or cracked pipe. In this street the pipe is laid in the sewer trench, which was excavated through rock. When the street was paved in 1893 house services had been placed every sixty feet. No large main leak was encountered, but seven service leaks were discovered and shut off at the main, which accounted for 700,000 gallons, or practically the entire waste. The corporation cocks had in nearly every instance been destroyed and water was discharging directly into the sewer. No indications of these leaks appeared on the street surface.

As work was completed in each division a permanent map was filed in the office, showing gauging points for the instrument and valves on boundary points. On this map is recorded the date of the first measurement, the 24-hour consumption and minimum night rate, and the same record of the second measurement. It is the intent of the Bureau of Water to continue the pitometer work as a special department and regular measurements will be taken at varied intervals, and these maps will facilitate the work greatly. All inspectors' reports are filed by streets and can be instantly referred to. As soon as a section was completed, a full report on it was submitted by the engineer-in-charge. This report gave a general summary of the work with certain specific recommendations to meet the conditions for the sections. These reports are filed so as to be available for future reference.

The report for Section 4 showed the following facts:

Total flow before inspection, gallons per twenty-four hours	17,936,000
Minimum night rate, gallons	14,912,000
Percentage of night rate to total flow	86.2

Inspection of all buildings on this section showed 3444 leaky fixtures divided as follows: faucets, 1064; toilets, 2380. It also disclosed 280 leaky services, which were repaired by the owners; 8 unfinished supplies, which were discharging into the sewer, were dug up and plugged. Also, one broken 6-inch main was uncovered and repaired.

After the house inspection and underground work was completed a re-measurement was taken with the following results: Reduction in daily consumption, 3,780,000 gallons; reduction in night rate, 3,910,000 gallons.

On account of the desire to reduce the pumpage as quickly as possible, so as to conserve coal as a war measure, no intensive work was attempted and the city was surveyed as rapidly as consistent with good work. It is highly probable that the results in this section could have been bettered had more time been devoted to it. However, by extending the work rapidly large leaks in other districts were detected and stopped in the time which might have been devoted to more intensive work in this section. It is expected that the work to be done in this section this summer will materially better the above result.

The efficiency of the survey as a means of reducing water consumption is shown by the monthly consumption chart, figure 2, which is a continuation of figure 1. Attention is called to the gradually increasing yearly consumption, as shown by the line AA, which in 1916-1917 showed a daily consumption of 168,000,000 gallons. Had no effort been made to check this the line indicates for the present year a daily pumpage of 186,000,000 gallons.

However, starting in July, 1917, which was co-incident with the start of the survey, each month shows a decrease in pumpage when compared with the same month in the preceding year except for the extremely cold months of December, 1917, and January and February, 1918. This chart brings out very clearly two conditions more or less peculiar to Buffalo. The summer months are usually higher than the monthly mean, while the months of December, January and February are excessively greater. Buffalo's homes are usually set well back from the street and surrounded by a grass plot. This not only applies to the homes of the well-to-do, but to the poorer classes as well. Practically half of the water bills have a sprinkling charge, indicating that the occupant uses a hose for sprinkling a lawn or street. From 5.00 to 9.00 o'clock on summer

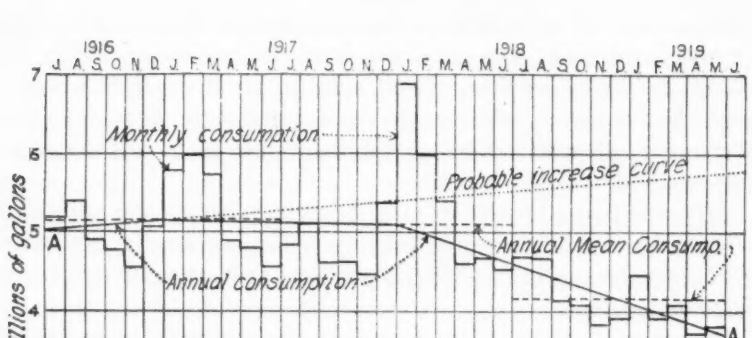


FIG. 2. WATER CONSUMPTION IN 1916–1919 (SEE TABLE 1)

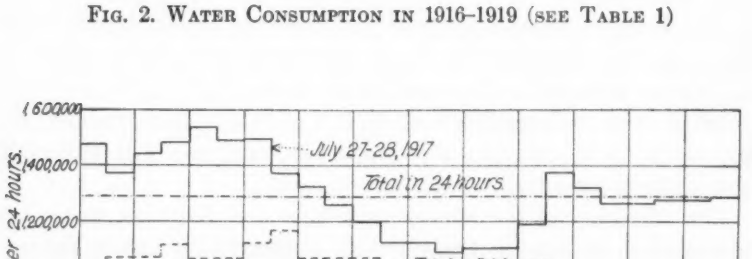


FIG. 3. CONSUMPTION IN A RESIDENTIAL DISTRICT WITH DWELLINGS OF A POOR CLASS, WITHOUT CELLARS AND GENERALLY WITH ANTI-FREEZING TOILETS. THE ONLY REDUCTION POSSIBLE IN TWELVE MONTHS WAS STOPPING UNDERGROUND LEAKAGE

	First measurement	*Second measurement*
Daily consumption, gallons	1,287,000	1,003,000
Minimum night rate, gallons	1,080,000	910,000
Population	4,670	4,670
Number of taps	667	667
Miles of main	6.2	6.2
Consumption per capita, gallons	275	214
Consumption per tap, gallons	1,929	1,503
Consumption per mile of main, gallons	214,500	167,166

nights, the department is apt to have close to its peak loads of the day at the stations, and the water used for sprinkling is enormous in the aggregate.

Besides this use in the summer time there is an excessive waste in the winter from the anti-freezing closet. Most of these have been installed in the older sections of the city and the majority

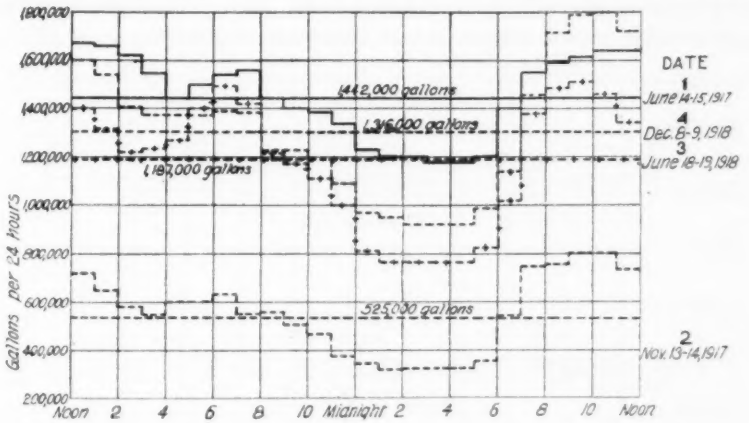


FIG. 4. CONSUMPTION IN A RESIDENTIAL DISTRICT WITH MIDDLE-CLASS DWELLINGS, THE ONLY COMMERCIAL CONSUMPTION BEING IN STORES

	First measurement before waste investigation	*Second measurement 5 months after survey*	*Third measurement twelve months later*	*Fourth measurement eighteen months later*
Daily consumption, gallons	1,442,000	525,000	1,187,000	1,316,000
Minimum night rate, gallons	1,175,000	316,000	775,000	925,000
Consumption per capita, gallons	128	46	105	116
Consumption per tap, gallons	536	195	441	489
Consumption per mile of main, gallons	75,900	27,639	62,473	69,263

Population, 11,273; number of taps, 2,600; miles of main, 19.2.

are in bad repair. The records show close to 10,000 of them still in use. Besides these the plumbing installation in many of the cheap houses has been such that to keep pipes from freezing it is necessary to allow water to run. The effect of this is shown by winter months' consumption.

More careful inspection of new plumbing is now being made and the anti-freezing closet is being gradually eliminated. When these are all done away with a great source of waste is gone.

Our first section was surveyed in 1917, and this year re-measurements have been taken. These show that there is a more or less gradual return of the waste first eliminated, depending wholly on the character of dwellings, as shown in figure 4. In all sections the consumption was less than it was two years ago at the time of the

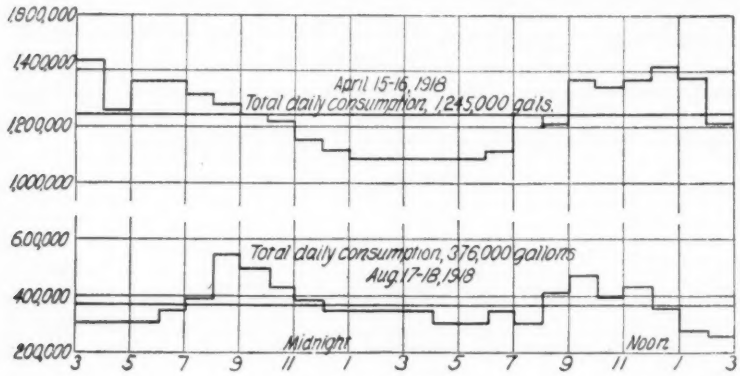


FIG. 5. DAILY CONSUMPTION IN HIGH-CLASS RESIDENTIAL DISTRICT BEFORE AND AFTER WASTE INVESTIGATION

	Daily consumption, gallons	*Minimum night rate, gallons*	*Consumption per capita, gallons*	*Consumption per tap, gallons*	*Consumption per mile of main, gallons*
Before investigation, April 15–16, 1918.....	1,245,000	1,185,000	394	1411	65,000
After investigation, August 17–19, 1918	376,000	260,000	119	426	19,790

Population, 3158; number of taps, 882; miles of main, 19. Very little house waste but a reduction of 869,000 gallons per day was made by stopping underground waste not showing on the surface.

first measurement. The author estimates that effects of the result of the survey will be from one to three years as far as house waste is concerned. All underground leaks stopped are a permanent saving.

In the sections completed the house waste stopped is estimated at 18,000,000 gallons, while the underground waste stopped was 12,000,000 gallons by actual measurements.

It is the intention to measure and sub-divide the entire city once in two years and to inspect completely as often. Of course measurements and inspections will be made oftener in the sections where waste is greatest. To control waste more fully in these sections meters will be placed gradually.

However, to reduce the pumpage quickly was imperative. The author knows of no other way which would have given results so quickly. To install meters would have taken from three to five years and the reduction would not have been felt for some time, at

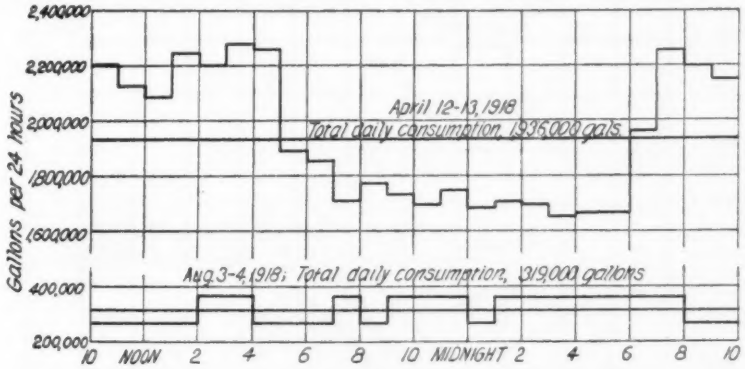


FIG. 6. DAILY CONSUMPTION IN A MIDDLE-CLASS RESIDENTIAL AND MANUFACTURING DISTRICT BEFORE AND AFTER WASTE INVESTIGATION

	Daily consumption, gallons	*Minimum night rate, gallons*	*Consumption per capita, gallons*	*Consumption per tap, gallons*	*Consumption per mile of main, gallons*
Before investigation, April 12–13, 1918..	1,936,000	1,655,000	1.001	4,976	16,500
After investigation, August 3–4, 1918..	319,000	260,000	165	820	2,726

Population, 1934; number of taps, 389; miles of main, 11.7.

least not for the first six months when the size of the bill would have brought the waste of water home very forcibly to the householder.

Figures 7 and 8 show the daily consumption divided as well as possible for the years 1917 and 1919. In this chart the legitimate household use is assumed at 50 gallons per capita per day. The industrial use is assumed to be the total metered use, as practically all industries are metered. This use is practically 100 gallons per capita per day. It is hard to account for such a large industrial use of water per capita in a city the size of Buffalo. In the author's

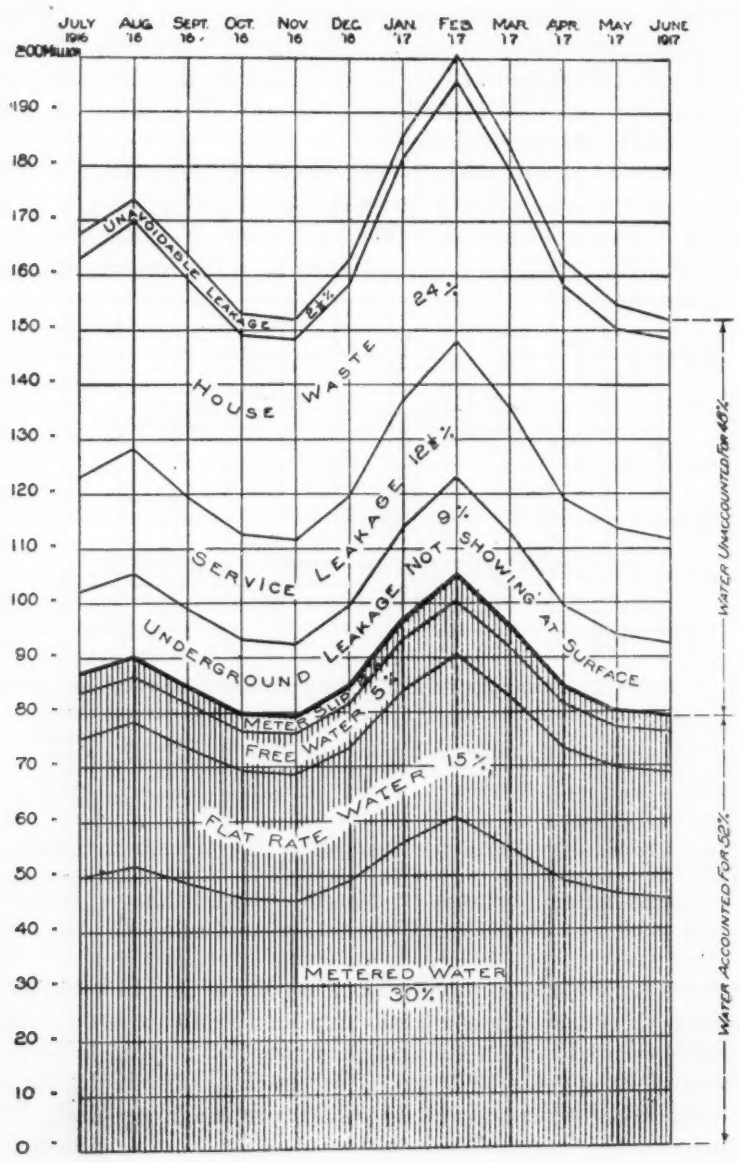


FIG. 7. SUB-DIVISION OF USE AND WASTE OF WATER IN 1916–1917

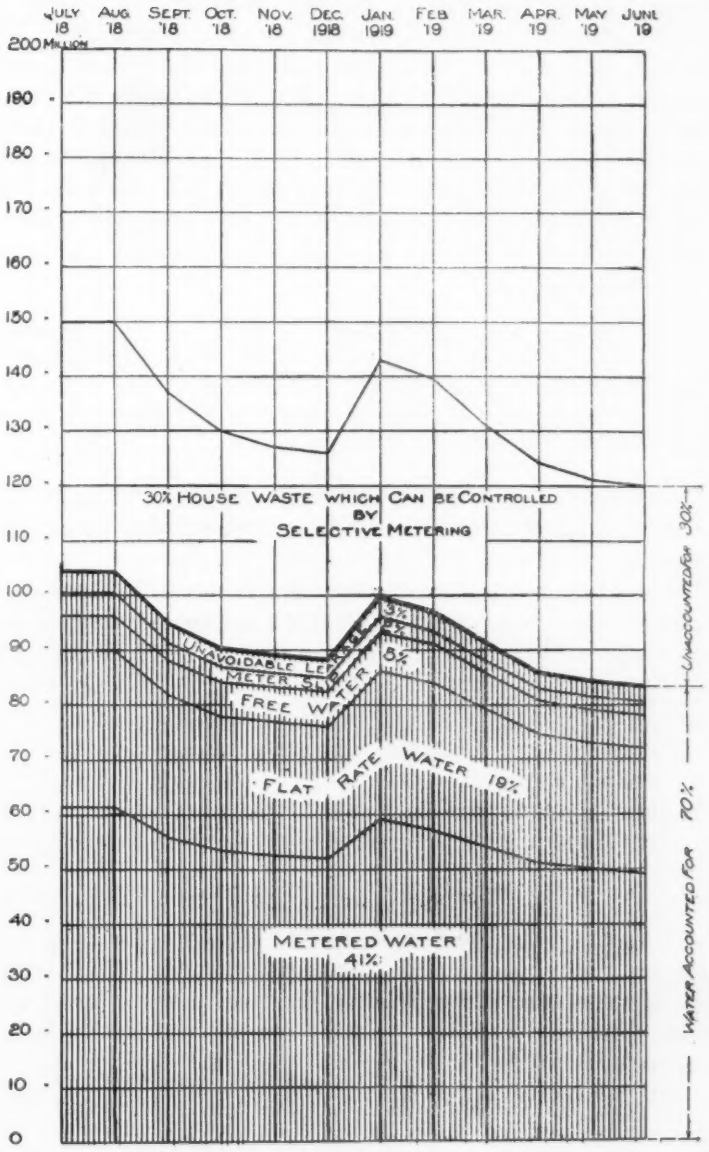


FIG. 8. SUBDIVISION OF USE AND WASTE OF WATER IN 1918–1919

opinion it is directly due to the low meter rate of 2 cents per thousand gallons which for a long time was the charge here. This, in conjunction with a fairly high minimum charge for a meter, made the average metered service user indifferent to the amount of water used. The larger consumer, as a rule, found it cheaper to waste water than to investigate for leaks. Buffalo is also a large railroad center and the city supplies all railroads with water. In 1917 the meter rate was raised to 4 cents per thousand gallons.

Nine-tenths of the city has now been covered by the survey with the following results:

Leaky fixtures reported and repaired	33,278
Leaky services reported and repaired	1,860
Unfinished supplies found wasting 3,587,000 gallons per day; broken mains and leaky joints wasting 4,376,000 gallons per day found and repaired	52

The services, broken mains, unfinished supplies and leaky joints repaired account for 12,000,000 gallons waste per day permanently stopped.

The pumpage has been reduced except in times of extremely hot or cold weather to less than 125,000,000 gallons per day, as compared to over 160,000,000 gallons per day in 1917. Figuring the cost of pumping at $6.24 per million gallons, the average cost for the last three years, the annual saving is $68,328. Against this is the estimated charge of $25,000 per year to maintain the pitometer division of the Bureau.

To date the survey has cost $96,931, much of which represents permanent investment in equipment and records or for professional services.

From the survey made and results obtained, it is evident that to a certain extent the house waste can be greatly reduced by house inspection controlled by pitometer measurements. When used in conjunction with selective metering the most flagrant house waste can be eliminated and the consumption reduced nearly to that obtained by universal metering and done at less expense. The pumpage can be reduced at least 20,000,000 gallons by the installation of 10,000 meters on house services where tremendous waste has been found by the survey. The installation of these meters is now proposed. A further reduction is not deemed advisable until a filtration plant is built.

A comparison between the cost of universal metering and the elimination and control of waste by the pitometer and selective metering is briefly as follows:

Control by pitometer and selective metering

Annual cost of inspection	$25,000.00
Installation of 10,000 meters, investment in meters $100,000	
Annual charge on meters, interest at 4½ per cent	4,500.00
Depreciation	4,000.00
Cost of reading and maintenance	6,000.00
Total annual cost	$39,500.00

Universal metering

Installation of 75,000 meters; investment in meters $750,000.00	
Annual charges on meters, interest at 4½ per cent	33,750.00
Depreciation 4 per cent	30,000.00
Cost of reading and maintenance	45,000.00
Total cost	$108,750.00

Annual saving in favor of pitometer control $69,250.

It is true that universal metering would reduce the consumption considerably more than the other method, but even if the reduction amounted to 20,000,000 gallons per day the saving in operation costs would not equal $69,250 per year.

The efficiency of any instrument is determined by how well it does what it is intended to do. If the object had been to reduce the consumption to a minimum the proper thing would have been to install meters and then eliminate underground waste by pitometer investigation. However, in any large water works there are certain features peculiar to it alone. For instance, the Buffalo Water Works had, at the time a reduction in pumpage was decided upon, two pumping stations capable of each supplying 150,000,000 gallons of water a day with mains properly built for distributing that quantity. If the pumpage is reduced to 110,000,000 gallons of water a day for nine months of the year, one plant can be shut down for that period. After that saving is effected, a further reduction in pumpage saves very little per million gallons pumped, as practically the same force is required to operate the plant whether

75,000,000 or 120,000,000 gallons is pumped, and irrespective of the pumpage, interest on the bonds accrues.

The intention was to reduce the pumpage from 159,000,000 gallons to less than 115,000,000 gallons by this survey and before the work is completed this result will have been attained. Moreover, the data have been furnished so it is known how to reduce the consumption further by intensive inspection and the installation of meters in certain districts.

PRACTICAL CHECKS UPON WATER-WORKS DEPRECIATION ESTIMATES

By Leonard Metcalf

The legal principles governing the determination and accounting of accrued depreciation have been fully discussed heretofore. The most complete analysis of them is to be found in the report of the "Special Committee to Formulate Principles and Methods for the Valuation of Railroad Property and Other Public Utilities," published in the *Proceedings of the American Society of Civil Engineers* in October, 1916.[1]

The discussion herein is limited to the presentation of some important records of actual depreciation developed in the practical administration of water works in different parts of the United States and to showing the necessity for keeping better records of plant abandonments as evidence of actual in contra-distinction to theoretical depreciation. Such records constitute a valuable aid to courts and commissions in fixing just allowances for depreciation in judicial determination, and to water works owners or departments in determining sound financial procedure and safe limits for depreciation accounting.

A striking example of the diversity of opinion sometimes encountered (resulting from an arbitrary following of mathematical and accounting methods), and of the steadying influence of actual records of depreciation in the shape of abandoned property, is to be found in the evidence submitted before the District Court of the United States of the Northern District of California, Second Division, in Spring Valley Water Company vs. City and County of San Francisco et al., Nos. 14275, 14735, 14892, 15131, 15344, 15569, 26, 96, heard in 1915–1916 by the Standing Master-in-Chancery, H. M. Wright, one of the ablest and most experienced judges in rate problems, who had had the advantage of hearing just before this case that of the Contra Costa Water Company vs. City of Oakland et al.

[1] *Transactions*, vol. lxxxi, December, 1917, p. 1311.

After discussing the theoretical principles governing the accounting and determination of depreciation Judge Wright says, in comment upon the practical aspect of the problem:

There is no fixed formula for determining what present condition, and consequent present value of a structure, is. Different structures will be differently treated in this respect. The solution of the problem requires the highest exercise of sound judgment. Careful inspection must be made of each structure. The experience of other plants must be borne in mind. The experience of the particular plant must be studied to gain an idea of the rate of depreciation in the past; consideration must be given to influences that may change that rate for the future and so determine the interval that will intervene before replacement is necessary. . . . .

The city's witnesses A and B, find depreciated worth and proper annual allowance by the straight line method. A finds on an estimated reproduction cost of $19,092,000 for all structures, an accrued depreciation in worth of $5,039,000, or 26.4 per cent. . . . . The percentage of depreciation seems excessive when compared with the experience of other plants of similar age. It also strikes me forcibly that so heavy a depreciation as 26.4 per cent is inconsistent with the witness's high commendation of the structural excellence and splendid present condition of the plant. In commending the plant in this way, (and very properly, for all the witnesses are in agreement) the witness had in mind a justification of his estimates of future life, which are longer than those of X and Y (the company's witnesses) rather than of his estimates of present condition and value. It is to be remarked that if he had not adopted long lives, his accrued depreciation would have been still heavier, too great perhaps for the witness himself to justify.

B (the city's other witness) also uses straight line methods. With estimated reproduction cost new of $18,461,000, he gets thus an estimated accrued depreciation of $5,150,000, or 27.9 per cent. He frankly acknowledges that his depreciation in value is attained by the mechanics of his accounting method, by elapsed life rather than by inspection of present condition. He adopts the straight line method because it is simpler in computation; he says "the general principle, 'whatever simplifies serves and whatever complicates is bad,' warrants its adoption." For accounting purposes this may be true, but it obviously results most unjustly in determining the present value of a waterworks midway of its life, whether for rate fixing or condemnation. . . . . The straight line theory takes no account of interest.

X (one of the Company's witnesses) determined the depreciated condition of the various units at the same time as he did the reproduction cost, accumulating the data for both by an actual inspection in the field performed with great thoroughness. He made careful study of the past history of the plant in the matter of depreciation and abandonments. . . . . Where our experience with this or other works enables us to form reliable judgments as to the total life-expectancy of particular classes, of structures, such as flumes, pumps or boilers, he uses a 5 per cent sinking fund curve as a measure of present condition, applied to the life in question. In particular cases, as of

hard service, or poor design of pumps, he sometimes estimates percentage condition at once by an effort of judgment. . . . . This brief survey will illustrate the practical nature of X's methods of determining present percentage condition.

Y's estimate (the other Company's witness) of accrued depreciation follows much more closely the sinking fund method on a 4 per cent curve of depreciation. He likewise made close investigation, by inspection in the field, of present condition of structures. While X's mental attitude is to estimate percentage condition first, and deduce remaining lives from that, Y finds it easier and deems it safe to work from a life estimate primarily, adopted from his experience, and check the resulting percentage condition, as to its reasonableness, by inspection and consideration of all surrounding conditions.

The Company's estimates of accrued depreciation amounted respectively to $3,192,455 or *12.7 per cent* on a gross reproduction cost of $25,125,843; and $3,496,847 or *13.9 per cent* on $25,128,930. After certain eliminations the Master refers to these percentages as *12.1 per cent* and *13.7 per cent*. On careful analysis of the evidence submitted the Master concludes:

At best the determination is an estimate. . . . . A figure of *13 per cent* seems to me fair. This gives a deduction from gross reproduction cost new, $21,537,000, of $2,800,000. Expressed as a percentage of structures subject to depreciation, rather than of all the structures, (for the Master eliminated some structures, such as the large storage reservoirs and certain of the tunnels as not subject to depreciation), this sum of $2,800,000 would be a larger percentage, perhaps 16 per cent, but I have not thought it important to make the computation.

While the Master's conclusion was undoubtedly the result of that judicial discrimination and weighing of the evidence which the law contemplates, it seems highly probable, and his comments indicate, that the actual historical record of abandonments in this particular plant during its life history of fifty-five years, and similar evidence of the life history of structural water works properties elsewhere, was of material assistance to him in making his decision. The historical evidence relating to the fair annual depreciation allowance may not have been equally helpful to him, because of the considerable range in results adduced in the small number of plants—five—the life history of which was cited.

It cannot be doubted, however, that a wider range of historic record, which can be had at the slight expense of the keeping by public service corporations of more systematic records of abandonments, will be found helpful and serve to prevent the carrying of theoretical deductions and methods of accounting to unwarranted limits.

It was with this end in view that Allen Hazen and the author have been trying for the past fifteen years or more to gather well-authenticated complete historic records of abandonments of structures by water-works properties in this country. The record of eleven works may seem meager for so long a period of years, but this merely indicates the imperfect character of corporation records of plant abandonments and the difficulty of assembling reliable information relating to them. The results which follow may serve, however, as a nucleus, and may stimulate further contribution from others who may have been doing the same thing and the future search for similar available information.

In comment upon these records the following notes are of significance.

Of the eleven records submitted, five were published, in skeleton only, as Appendix IV of the Committee's report[2] heretofore alluded to, with the following significant introduction,—

RECORDS OF ABANDONED PROPERTY

The Committee calls the attention of engineers and administrators of public utility properties to the desirability of keeping as clear and complete a record as possible of the property abandoned by the corporation, annually and in aggregate amount.

Such records will be of great service to courts and commissions, in assisting them to determine the annual depreciation allowance which should fairly be made for any public utility property, in the light of its past history, as well as of an intelligent forecast of its probable future.

It is obvious that such record—when used as a check upon, or when coupled with, an estimate of the accrued depreciation on the existing property,—will reduce substantially the element of uncertainty, which must attend all such computations, based, as they must always be, upon probable future, as well as on past conditions.

As an example of such records within the waterworks field, and of their applicability, the following table is cited, embodying the results of a continuous effort to collect such data, during a period of fifteen years more or less, on the part of Allen Hazen and Leonard Metcalf, Members Am. Soc. C. E.

It seems highly probable that by keeping such records in detail, there will be developed, in the course of time, sufficient information to admit of the setting aside of the fair annual depreciation allowance on a basis of percentage-of-gross-revenue of the operating company, a method which would have much advantage, on account of its simplicity of accounting, as well as for other reasons.

[2] *Transactions American Society Civil Engineers*, vol. lxxxi, December, 1917, p. 1582.

Inasmuch as this table is submitted for suggestive purposes only, and not for direct application, it is unnecessary to record here a description of the various plants, or the methods of determining the figures contained in the record, though it may be added that these figures have been taken in large measure from authoritative sources, such as court, commission or agreed, findings.

The figures then submitted have since been slightly revised to accord with the Master's and court's decision in the Spring Valley Water Company case, somewhat expanded and materially added to. To make the record of service to others, brief notes follow, characterizing the plants, the depreciation records of which are submitted.

Portland, Maine, (1907. Hazen and Metcalf.) The statistics relate to the works of the Portland Water Company and three subsidiary companies taken together and treated as one plant. The estimated cost of reproduction was agreed upon by four engineers, two representing each side, in a proceeding that resulted in a transfer of the property. These engineers did not agree upon the depreciation but each made his own estimate. The depreciation estimates differed considerably on the two sides,—though all four engineers used the sinking fund basis of determination, checked by careful inspection of structures themselves,—and the average of the four is taken. The plant was peculiar in that some of the main parts had ceased to be adequate, and while they were in fair physical condition and capable of service for many years, the needs of the district were such that new works were required to replace them. Under these conditions a functional depreciation was claimed by the engineers representing the Water District in excess of physical depreciation and it is largely to this fact that the relatively high annual depreciation found by the computations must be attributed.

It may also be noted that some expensive parts of the works had been built with inadequate engineering advice and were not very well adapted to the service required of them, and this also was a matter taken into account in estimating the depreciation on existing structures.

Racine, Wis., Water Company (1913, Hazen). The values and the estimated depreciation are those made by Allen Hazen in valuing the plant in 1913. The cost of the discarded structures was estimated by the local manager from quite full records. The Racine plant was very well built, future growth was liberally anticipated and the growth of the city has not been so rapid as to make it necessary to discard any important part of the plant. The Lake Michigan water dispensed by it is remarkable for the small effect which it has upon the pipes through which it flows, and this tended to reduce depreciation. Taking these matters into account, the depreciation at Racine must be considered as unusually low and much below the average. The plant is also a comparatively young one and this may have some effect.

Denver Union Water Company, Denver, Colo. (1913, Metcalf). The record of the Denver Union Water Company data was prepared at the time of the trial of the rating suit (May, 1914,) the basic valuation being made as of October 31, 1913.

The Denver plant comprises some structures relatively less durable than those of the Spring Valley Water Company or of the Portland Water District, which has increased the rate of depreciation. These structures are the main conduit lines, upwards of 100 miles in length, built of wood stave pipe, whereas the Spring Valley Water Company conduits were built of wrought iron. The pumping plants are also of somewhat less substantial type. The dams and distribution pipe systems, on the other hand, are of equally enduring type.

A considerable depreciation in abandoned property resulted at Denver from bitter competition just prior to the consolidation of the two predecessor companies which were united in the Denver Union Water Company about the year 1894, and which themselves represented a consolidation of several smaller companies.

The engineers to the Public Utilities Commission of Denver rejected the straight line method of determining depreciation, as giving extreme results repugnant to their judgment, and, as the engineers to the Company, adopted the sinking fund basis (with 4 per cent rate), checked by careful examination of the structures themselves. The Master's depreciation figures were in close accord with the author's and but slightly different from those of the City's representatives.

The Denver depreciation has been figured on the basis of the author's detailed analysis and the Master's findings. The latter excluded from the rating base the Sullivan Reservoir, the paving-over-mains, and some of the street obstructions.

Pennsylvania Water Company, Wilkinsburg, Pa. (1911, Metcalf). This record was obtained by the author April, 1911, assisted by the Engineer and General Manager of the Company, William C. Hawley, M.Am.Soc.C.E.

These works supply certain wards of the City of Pittsburg, the City of Wilkinsburg and a number of other cities or towns stretching for a distance of fifteen miles, more or less, to the east of Pittsburg and then comprising a population of about 90,000.

The plant is located in the heart of the steel manufacturing district and operates under very trying circumstances, supplying water at varying elevations up to 600 feet above the source of supply. The first supply was derived from the Monongahela River which had to be abandoned, except as an emergency supply, on account of the change in character of this water due to mining operations on the river which made the water too acid for domestic use. The new supply, comes from the Allegheny River and has to be lifted approximately 600 feet on to the top of a hill where it is filtered and distributed to the various levels of the city.

The records of the Pennsylvania Water Company indicate that the average annual rate of depreciation for the period of years from the construction of the plant in 1888–1889 to the date of valuation, 1911, was 1.3 per cent of the gross reproduction cost of the structures, which probably, but lightly exceeded their original cost; and that the annual depreciation amounts to approximately 8 per cent of the gross annual revenue during this period of years. In comment upon the latter figure, it is to be noted that the gross annual revenue was found to be inadequate in the rating case (1911) and that the revenue after the enforcement of the new rate schedule was substantially increased. Had

the actual revenues been on the higher adjudicated scale, it would have had the effect of decreasing the depreciation (8 per cent) shown above as measured in terms of the gross annual revenue. The data are, however, not sufficiently exact to justify any such reduction, but it is probably fair to assume that the stated allowance of 8 per cent of gross annual revenue is a fairly reasonable one.

Spring Valley Water Company, San Francisco, Cal. (1913, Metcalf). The structures of the Spring Valley Water Company are of an unusually well built and enduring kind. The earthen and masonry storage reservoirs are very substantially built, and are likely to be used for a very long period of years, if not for all time. The conduit lines were built of wrought iron and coated by Hermann Schussler, M. Am. Soc. C. E., with a special coating and after varying periods of service up to 45 years show remarkable freedom from corrosion or tuberculation. The pumping plants are of very substantial character. The distributing reservoirs are well built, and the distributing system is good and sound, though it will require reinforcement in certain sections with increase in density in population.

The abandoned-structures and structures-never-in-use in the system of the Spring Valley Water Company amount to $3,420,000, being nearly equal in amount to the accrued depreciation upon the existing structures.

The figures are based upon the findings of Hon. H. M. Wright, Standing Master in Chancery of the U. S. Federal Court of the Northern District of California, rendered in 1917, as of date December 31, 1913.

Indianapolis Water Company, Indiana, (1915, Metcalf). This record was obtained by the author from the records and officers and employees of the Company, in November, 1916.

The works of the Indianapolis Water Company are of very substantial type. The pipe system is substantially wholly of cast iron and of unsually ample dimensions. The pumping stations have been well built and equipped with heavy machinery of very good efficiency, the old Snow pump for many years holding the record for the highest duty developed by any triple-expansion flywheel engine in this country and still operating very economically. A very important element of the property is the canal approximately 9 miles long, delivering the water supply by gravity to the coagulating basins and filters, and the balance of the water to the Washington Street Station in the heart of the city, where power is developed from it to pump the filtered water to the consumer. The canal is without probability of abandonment or material depreciation, and constitutes perhaps one-sixth, more or less, of the entire property. The filter plant and appurtenant structures are of good type, though some extension of the plant and modification in method of operation may be necessary in the future when the city grows to materially larger dimensions.

The property may be characterized as one of the best-built and maintained water works in the United States.

East Chicago and Indiana Harbor Water Company, Indiana (1917, Metcalf). Record worked up in connection with the hearings upon the petition of the city, for filtered water, before the Public Utility Commission of Indiana, though much of the data was assembled during the period from 1904 to 1912

during which the author represented the bondholders and the owners of the property in the supervision of the management of the works.

This is a record of abnomally high depreciation developed in a city which has grown unusually rapidly, increasing from a population of 1255 in 1890, and 3411 in 1900, to 19,098 in 1910, and 33,000 in 1917.

The original works were cheaply built and the original machinery had soon to be superseded. The greater part of the depreciation is due to the abandonment of one of the lake intake pipe lines, 3,000 feet in length, of 16-inch spiral riveted flanged steel pipe. It accounts for $40,000 out of a total property abandonment of $94,000.

The present plant is a substantially built one, of the pumping type.

A Central New York Plant (1916, Metcalf). The record of the depreciation data was worked up from the records of the Company, with the assistance of the older employees, as of December 31, 1916.

The structural plant has been built largely within the past 20 years. The plant has been well built and is of long-lived character. It consists of large storage reservoirs located on opposite sides of the city, built in most cases of earth with paved slopes, cast iron supply mains 20-inch and upward in diameter, bringing the water to the city; and cast iron distribution pipe system of fair size with feeders of good capacity. The booster pumping plants are of minor character and small cost.

The amount of depreciation fully developed in the form of abandoned property is comparatively small, the chief items being an earthen dam which burst during a flood, and the distribution pipe system replaced with mains of larger diameter.

Concord, Mass., Water Works—Municipal (1917, Leonard Metcalf, Chairman of Water and Sewer Commissioners). The Concord water works were built originally in 1874, by William Wheeler, M. Am. Soc. C. E., and consisted of a gravity supply fom Sandy Pond, delivered through wrought iron cement-lined mains 10 inches and smaller in diameter, to Nashawtuc Reservoir. They were substantially reinforced by the addition of a second main of wrought iron cement-lined pipe, from Sandy Pond to the center of the town, in 1883. Some additional wrought iron cement-lined pipe was laid in the interval between these two dates and subsequently as late as 1890, the total amount aggregating an approximate cost of $142,000.

In 1909 additional gravity supply was obtained from Nagog Pond, on the opposite side of the town from the old supply and delivered through a compound 16-inch and 12-inch cast iron pipe line into a high service fire protection system, by small motor-driven centrifugal pump, boosting the water from the low service into the high service mains, storing water in a new reservoir (Annursnack) of 2,500,000 gallons capacity. The works were well-built and the original use of wrought iron cement-lined pipe in preference to the then more costly cast iron pipe was well justified, as the life history of the plant has demonstrated. Owing in part to the construction of the sewer system, which resulted in lowering the ground water table, and in some settlement of the water pipe system, as well as to the effect upon the low-service system pipe of the subsequently introduced high-service supply (put upon the mains during times of fire), wrought iron cement-lined pipe of an aggregate cost of approxi-

mately $20,800 had to be replaced with cast iron pipe, and it is probable that the life of the remainder of the wrought iron cement-lined pipe will be substantially shorter than would have been the case with cast iron pipe.

The record of accrued depreciation within the life history of the plant, from 1874 to 1917, both inclusive, has therefore been figured upon two bases,

Actual depreciation of Concord, Mass., water works, and depreciation figured on plant using cast iron pipe

ITEMS	ON BASIS OF EXISTING PLANT	ON MODIFIED BASIS OF CAST IRON PIPE INSTEAD OF WROUGHT IRON CEMENT-LINED PIPE
Date of record	Dec. 31, 1917	Dec. 31, 1917
Authority	Metcalf	Metcalf
Population	6,733	6,733
Whole period of operation in years	44	44
Average age of investment in years	18.3	18.3
Gross revenue during whole operating period	$703,000	$703,000
Gross cost of existing structures	$380,200	$380,200
Cost of abandoned structures	$41,200	$ 31,200
Combined cost of existing and abandoned structures	$421,400	$411,400
Accrued depreciation on existing structures	$68,700	$42,200
Accrued depreciation on existing structures expressed as percentage	18.1%	11.1%
Accrued depreciation in abandoned structures	41,200	31,200
Accrued depreciation in abandoned structures expressed as percentage	9.8%	7.6%
Total depreciation in amount	$109,900	$73,400
Total depreciation in percentage on cost of existing and abandoned plant	26.1%	17.8%
Total depreciation in percentage on cost of existing plant	30%	19.8%
Average annual depreciation in percentage based upon		
(a) cost of existing plus abandoned structures	1.42%	0.98%
(b) Net or depreciated cost of existing structures only	1.64%	1.08%
(c) gross revenue, during whole operating period	15.6%	10.4%
(d) per capita (total depreciation divided by present population times average age)	89¢	59.7¢

the first, the system as it stands, the second upon a modification of the accrued depreciation to determine the difference which would probably have resulted had cast iron pipe been used instead of wrought iron cement-lined pipe, for the purpose of comparing this record with other similar data.

In making the analysis on a cast iron pipe basis, it has been assumed that the abandoned wrought iron cement-lined pipe, aggregating $20,800 approximately, would probably have been reduced by the sum of at least $10,000; and that the average life of the cast iron pipe system assumed to replace the existing wrought iron pipe system, would have been 75 years, instead of 50 years assumed for the latter, much of which is already 43 years old. Under these circumstances the accrued depreciation upon the existing pipe system (with cast iron substituted for wrought iron cement-lined pipe) would be $13,500, instead of $40,000, and the total accrued depreciation upon existing plant would be reduced from $68,700 to $42,200. The comparative results are shown on preceding page.

A southern seaboard state plant (1917, Metcalf). The record of total depreciation upon this plant was worked up by the author with the assistance of the officers of the Company, in connection with the valuation of the property as of December 31, 1917.

The works were originally built in 1888, but owing to the abnormally rapid growth of the city, beginning about 1906, the average age of the investment is but 10 years.

The plant consists of a driven well system, the older wells being 10 inches in diameter for the most part, and varying in depth from 165 to 320 feet, running into the Vicksburg limestone, the water supply being pumped by reciprocating pumps, substantially a direct pressure system, operating under 65 pounds per square inch pressure, more or less, increased to 100 pounds at times of fire.

The wells recently built (Substations 1 and 2) are 12 and 15 inches in diameter, approximately 240 to 300 feet deep. They are equipped with motor-driven, two-stage, centrifugal pumps.

The pipe system is of cast iron of good dimensions. The 3,500,000 gallon reinforced concrete storage reservoir built in 1915, is a well built structure of this type. The works are of good character.

Portsmouth, Berkley and Suffolk Water Company, Va. (1918, Metcalf). This record was obtained by the author sitting as one of a board of three arbitrators appointed to fix the fair value of the property of the company as of April 1, 1918.

The present company was incorporated in 1902 and comprised predecessor companies built in the late eighties. Its water supply, which is ample for the growing population, is derived from the Suffolk lakes, probably the most available and desirable water supply in this general region, developed by substantial storage dams. The water, which is of good quality though somewhat hard and high in color as are the waters of this region, is lifted to and passes through coagulating basins, aerators and mechanical filters, and is then pumped, by compound condensing double-acting duplex pumps, at a pressure of 100 pounds per square inch, into and transported through cast iron conduits a distance of about 18 miles to Portsmouth. Substantially all of this

pressure head is consumed in overcoming the frictional resistance in this distance, and at Portsmouth the water is repumped into a standpipe and to the consumers by pumps of similar type. A 14-inch flexible-joint, cast iron pipe line carries the water under the harbor (the Elizabeth River) to the Berkley standpipe and consumers.

The distribution pipe system is largely of cast iron pipe, though there is a considerable percentage of small wrought iron pipe supplying sections of the city without fire hydrant service. The plant is fairly characteristic of early water works practice in this country, conscientiously built and well maintained under difficult natural and financial conditions.

The depreciation estimate was made on the sinking fund basis, on age and expectancy of life figures submitted by the engineers to the parties at issue, and was subsequently analyzed and modified by one of the members of the Board, as a basis for its discussion. It served as an aid to judgment, though it was not acted upon by the Board, except in so far as weight may have attached to it in its bearing upon net reproduction cost or other measure of value considered in the final determination of the fair value of the property.

COMMENTS UPON ELEVEN RECORDS CITED IN TABLE 1

The record covers eleven water-works properties serving cities from 6700 to 500,000 population.

The range of age or elapsed life varies from twenty-two to sixty-seven years; the corresponding average age of investment, from eleven to twenty-six years, the difference between the two being due to the fact that the construction work during the more recent years has been greater than in the earlier years of the life history of the plants under consideration.

The gross revenue earned during the whole operating life of each of the plants was obtained from its records. In some cases, owing to lack of available data, the revenue during the first few years of the plant's life had to be estimated from the best evidence available, but the effect of any probable error in the correctness of this estimate is likely to be insignificant in the resulting averages and certainly within the limits of accuracy or direct applicability of such records.

The original cost of the structures includes the actual, or a moderate allowance for the estimated, overhead and interest-during-construction charges, on the assumption that the overhead costs were partly carried by operating expenses. Where reproduction costs had to be used, fair allowance has been made, and in all cases similar bases of cost have been used for the analyses of annual and accrued depreciation. The cost shown does not represent the cost or the fair value of the entire property in any instance cited, because it

excludes real estate, going value, water rights, intangible values and perhaps some other items or elements of value. It covers structure costs only. The Denver and San Francisco figures are based upon Federal Court decision; the Indianapolis, upon Public Service Commission finding; the Portland, upon an average of the contentions of the plaintiff and defendant, which differed by about 3 per cent, if the author's memory serves him rightly; the East Chicago, upon a valuation by John W. Alvord, M. Am. Soc. C. E., roughly checked by the author and varying but little from the contentions of the city's representative, Samuel A. Greeley, M. Am. Soc. C. E., and the six remaining cases were based upon the analyses of Allen Hazen, Emil Kuichling and the author, respectively.

The abandoned structures were determined from the corporate records in every case, with the assistance of the employees having the best information concerning the structures, the original cost being used where available, otherwise the reproduction cost.

The accrued depreciation upon the existing structures was estimated after examining the property and the records of the Company, careful study of the records of abandoned structures, using the sinking fund method (see later discussion on reason for using this method) of computation, based upon elapsed life, with 4 per cent interest rate, merely as an aid to judgment; giving consideration also to other practical factors such, for instance, as those revealed by inspection, by the operating records, by repair accounts and by the loss in carrying capacity of the pipe distribution system. Where available, the finding of the court as to the accrued depreciation upon existing structures was utilized; otherwise an average of the witnesses for the plaintiff and defendants or the estimate of the individual as stated.

Where these estimates of accrued depreciation upon existing property are in error, the total depreciation estimate also will be in error, but in much smaller measure, as the amount of the abandoned structures, which is known, is also involved. It may be noted, too, that the estimates upon all but the Racine case were made by the same person whose depreciation estimates were in close consonance with the finding of the Federal Court in the Denver and San Francisco cases.

The accrued depreciation upon existing structures, shown in total and average annual percentage, is based upon the existing structures only; that of the abandoned structures upon the combined amount of existing and abandoned structures.

	PORTLAND, ME., WATER DIST. (AVERAGE OF PLAINTIFF AND DEFENDANT)	RACINE, WIS. (HAZEN)	DENVER UNION WATER COMPANY, COLO. (FEDERAL COURT)	PENN WI
1. Date of record	1907	1913	1913	
2. Authority	Hazen and Metcalf	Hazen	Metcalf	
3. Population	78,200	38,000	242,000	
4. Whole period of operation, years	39	26	43	
5. Average age of investment, years	18	16	20	
6. Gross revenue during whole operating period	$6,605,000	$1,343,000	$22,000,000	
7. Gross reproduction cost of structures	2,594,000	1,219,000	10,411,438	
8. Abandoned structures (actual or reproduction) cost.	137,000	19,000	1,420,505	
9. Total (including overhead and interest during construction)	$2,731,000	$1,238,000	$11,831,943	
10. *Accrued depreciation* on existing structures (reproduction cost)	$498,000 = 19.2%	$70,600 = 5.8%	$1,320,970 = 12.7%	$27
11. Accrued depreciation—in abandoned structures, actual (or reproduction) cost	137,000 = 5.0%	19,100 = 1.5%	1,420,505‡ = 12.0%	250
12. Total amount in existing and abandoned structures.	$635,000	$89,700	$2,741,475	$521
13. Total depreciation in per cent on gross reproduction cost (on existing and abandoned structures)	23.2%	7.2%	23.2%	
14. Total depreciation in per cent on average net reproduction cost of existing structures (see 21 below)	26.3%	7.5%	26.2%	
Average annual depreciation in per cent based upon				
15. (a) Gross reproduction cost and abandoned structures	$\frac{23.2}{18} = 1.29\%$	$\frac{7.2}{16} = 0.45\%$	$\frac{23.2}{20} = 1.16\%$	$\frac{15.}{12}$
16. (b) Net reproduction cost of existing structures only, or gross reproduction plus abandonments, less one-half total depreciation, divided by average age	$\frac{26.2}{18} = 1.46\%$	$\frac{7.5}{16} = 0.47\%$	$\frac{26.2}{20} = 1.31\%$	$\frac{16}{1}$
17. (c) Gross revenue during whole operating period	9.6%	6.7%	12.4%	
18. (d) Per capita (total depreciation divided by present population times average age)	$0.45	$0.15	$0.57	
19. Gross reproduction existing and abandoned property.	$2,731,000	$1,238,000	$11,831,943	
20. Minus one-half combined depreciation	317,500	44.850	1,370,737	
21. Average net reproduction cost	$2,413,500	$1,193,150	$10,461,206	

* See notes upon this property showing effect upon depreciation record of the wrought iron cement lined pipes and probab

† Figures 7.52 per cent. 8 per cent believed to be a fairer figure, however.

‡ Including Sullivan reservoir.

§ On basis of original cost of structures of $21,306,000, a straight-line depreciation rate of 1.5 per cent was found to yield $6

|| Heavy depreciation due to use of iron cement-lined pipe.

¶ Based upon decision Indiana Public Service Commission, March 15, 1917.

** 14.2 years (approximate) on sinking fund basis applied to existing structures.

†† Based upon decision of Judge H. M. Wright, Standing Master in Chancery. United State District Court, Northern Dist

‡‡ Average plaintiff and defendant engineers.

§§ Prewar prices.

TABLE 1

Depreciation records of some old water works

DENVER UNION WATER COMPANY, COLO. (FEDERAL COURT)	PENNSYLVANIA WATER COMPANY WILKINSBURG, PA. (METCALF)	SPRING VALLEY WATER COMPANY SAN FRANCISCO, CAL. (FEDERAL COURT)††	INDIANAPOLIS WATER COMPANY INDIANAPOLIS, INDIANA (PUBLIC SERVICE COMMISSION) ¶	E. CHICAGO AND INDIANA HARBOR WATER COMPANY E. CHICAGO, IND.‡‡	A CENTRAL NEW YORK PLANT (METCALF)	CO
1913 Metcalf 242,000 43 20	1911 Metcalf 90,000 23 12	1913 Hazen and Metcalf 453,000 55 26	December, 1915 Metcalf 270,000 45 16**	November, 1915 Metcalf 29,600 22 11	December 31, 1916 Metcalf 102,000 67 22	
$22,000,000	$3,923,000	$76,968,000	$13,972,000	$805,000 (est.)	$6,841,000	
10,411,438 1,420,505	3,128,389 250,000	21,537,000 3,420,000	7,906,000 883,000	609,400 94,400	4,509,000 285,000	
$11,831,943	$3,378,389	$24,957,000	$8,789,000	$703,800	$4,794,000	
$1,320,970 = 12.7%	$271,700 = 8.7%	$2,800,000 = 13%	$736,000 = 9.3%	$63,500 = 10.4%	$353,000 = 7.8%	$68
1,420,505‡=12.0% $2,741,475	250,000 = 7.4% $521,700	3,420,000 = 13.7% $6,220,000	883,000 = 10.0% $1,619,000	94,400 = 13.4% $157,900	285,000 = 6.3% $638,000	41 $109
23.2%	15.4%	24.9%	18.4%	22.4%	13.3%	
26.2%	16.7%	28.5%	20.3%	25.3%	14.1%	
$\frac{23.2}{20}$ = 1.16%	$\frac{15.4}{12}$ = 1.29%	$\frac{24.9}{26}$ = 0.96%§	1.13%	$\frac{22.4}{11}$ = 2.04%	0.62%	$\frac{26.}{18.}$
$\frac{26.2}{20}$ = 1.31%	$\frac{16.7}{12}$ = 1.39%	$\frac{28.5}{26}$ = 1.10%	1.23%	$\frac{25.3}{11}$ = 2.3%	0.66%	$\frac{30}{18.}$
12.4%	8.00%†	8.1%	11.6%	19.6%	9.3%	
$0.57	$0.48	$0.53	$0.42	$0.48	$0.29	
$11,831,943 1,370,737	$3,378,389 260,850	$24,957,000 3,110,000	$8,789,000 809,500	$703,800 78,950	$4,794,000 319,000	
$10,461,206	$3,117,539	$21,847,000	$7,979,500	$624,850	$4,475,000	

ent lined pipes and probable results had cast iron pipe been used to wit:—annual depreciation (a) = 0.98 per cent; (b) = 1.08 per c

cent was found to yield $6,774,000, depreciation allowance (including abandoned property) as of Dec. 31, 1913. Note that $\frac{\$21,306,000}{24,957,000}$

trict Court, Northern District of California, 1917.

ORE	CONCORD, MASS.* (METCALF)	A SOUTHERN SEABOARD PLANT (METCALF)	PORTSMOUTH, BERKLEY AND SUFFOLK WATER COMPANY, VA.	RANGE	ESTIMATED NORMAL AVERAGE (APPROXIMATE)
916		December 31, 1917	April 1, 1918		
	Metcalf	Metcalf	Metcalf		
	6,750	68,800	80,000	6,750–453,000	
	43	28	30	22–67	
	18.3	13	13.1	11–26	
	$703,000	$2,502,000	$3,983,000		
	380,200	913,118§§	2,009,000§§		
	41,200	40,000	165,000		
	$421,400	$953,118	2,174,000		
%	$68,700 = 18.1%	$118,000 = 12.93%	$186,000 = 9.2%	5.8%–19.2%	8%–13% Aver. 11.6%
%	41,200 = 9.8%	40,000 = 4.38%	$165.000	1.5%–16.1%	6%–12%
	$109,900	$158,000	$351,000 = 16.1%		Aver. 9.1%
	26.1%	16.6%	16.1%	7.2%–26.1%	Aver. 18.8%
	30.0%	18.05%	17.6%	7.5%–30.0%	Aver. 21.0%
	$\frac{26.1}{18.3} = 1.42\%$‖	$\frac{16.6}{13 \text{ yrs.}} = 1.28\%$	1.23%	0.45%–2.04%	0.9%–1.3% Aver. 1.17%
	$\frac{30}{18.3} = 1.64\%$	$\frac{18.05}{13 \text{ yrs.}} = 1.39\%$	1.34%	0.47%– 2.3%	1.0%–1.4% Aver. 1.3%
	15.6%	6.31%	8.8%	6.31%–19.6%	8%–12% Aver. 10.4%
	$0.89	$0.22	$0.33	$0.15–$0.89	$0.40–$0.50 Aver. 43¢
	$421,400	$953,118	$2,174,000		
	54.950	79,000	175,500		
	366,450	874,118	$1,998,500		

1.08 per cent; (c) =10.4 per cent; (d) = 60 cents.

$\frac{\$21,306,000}{24,957,000} \times 1.25$ per cent = 1.07 per cent, an approximate check.

The total depreciation in percentage of the average net or depreciated cost is found by dividing the combined amount of the depreciation upon existing and abandoned structures, by the combined cost of existing and abandoned structures, less one-half of the total depreciation, the latter being made up of the depreciation upon existing and abandoned structures.

The average *annual depreciation, in percentage of the cost or of the gross-reproduction-cost-of-existing-and-abandoned structures,* is found by dividing the total depreciation, expressed in percentage, by the average age of the investment (in structures only).

The average *annual depreciation, in percentage of the net-or-depreciated cost* is found by dividing the total percentage depreciation upon existing structures only, found as previously described, by the average age of investment in structures.

The average *annual depreciation, in percentage of gross-revenue* during the entire operating life of the plant, is found by dividing the total depreciation upon the existing and abandoned structures, by the gross revenue during the life history of the plant, and this quotient by the average age in years of the investment in structures.

The average *annual depreciation per capita* is found by dividing the total depreciation upon existing and abandoned structures, by the present population and this quotient by the average age in years of the investment in structures.

REASONS FOR USING SINKING FUND METHOD FOR DETERMINING ACCRUED DEPRECIATION UPON EXISTING STRUCTURES IN REFERENCE TO OTHER METHODS

First. In the present state of knowledge of depreciation actually developed or realized in different water works, and of fair provision for and accounting of depreciation in *water works property,* the sinking fund method has been found to more closely follow the true depreciation (in contradistinction to the theoretical accounting allowance) than any other, though it too must be applied in the light of the *observed conditions.*

Later when experience shall have crystallized into more specific, reliable and comprehensive record, it may well be possible to use simpler and more direct methods for determining actual accrued depreciation and fair annual depreciation allowance.

Second. As applied to *long-lived* properties such as water-works, it

is the method most generally used by engineers and others who have most thoroughly and judicially studied such records.

Third. While with *short-lived,* or *recently built* long-lived properties the difference resulting from the determination of accrued depreciation by the application of different methods, such as the straight line, the sinking fund, the equal-annual-payment, and others, to life expectancies of structures, is comparatively slight, this difference becomes seriously unfair with all long-lived properties.

It is generally found that when the straight line method of determining accrued depreciation is applied to water-works from twenty to forty years or more old, the result is obviously at variance with the actual condition of the structures and the service rendered by them, often so extremely so as to be repugnant to fair judgment. Thus, in the Denver rate case of 1913, the engineers to the Public Utilities Commission figured accrued depreciation by both the sinking fund and by the straight-line-method, and rejected the results obtained by the latter as being obviously excessive and out of line with the condition of the structures carefully observed by them. They finally adopted the sinking fund method, with 4 per cent rate, as a basis of computation for aiding and in many cases determining judgment. The results thus obtained were in fairly close accord with those found by the engineers to the Denver Union Water Company and those adopted by the Master of the Federal Court before whom the case was tried.

Similarly in the Spring Valley Water Company vs. City of San Francisco (1908–1916) alluded to at the beginning of this paper, the Standing Master in Chancery, Judge H. M. Wright, rejected the results obtained by the application of the straight-line-method to the determination of the accrued depreciation as excessive, unjust and unwarranted and adopted an amount in close accord with the result derived by sinking fund methods.

Judge Wright's comments are significant:

> The *modified sinking-fund method* is one of two correct methods by which depreciation may be amortized throughout the life of the structure, when the value thereof is depreciated each year. It is the only method which shows present worth in any year after the first.
>
> On the other hand, a defect of the *straight-line method* of amortization is that it casts the heavier burden of payments upon the ratepayer of the early years when revenues are low, and, expressed in terms of value of service, when the load-factor of the unit is low.

Now, I emphasize again the fact that we have been discussing accounting or book-keeping methods adopted to satisfy by current money payments, the ratepayer's obligation to pay the owner interest on the capital employed and to provide the capital necessary to replace a structure which depreciates in service; in other words, these are mere matters of arithmetic. All will work out justly if followed from the beginning to the end of the life of the structure. On the other hand, the necessary amortization will not be accomplished if any selected method is pursued only for part of the estimated life; or when one method is followed for part of the life and another method for the residue. This is self-evident.

It is also important to emphasize the fact that except in the first and last years, these various figures illustrative of cost-accounting methods bear no necessary relation to annual depreciation in value of the structure *in fact*, or to the depreciated value of the structure, its value for sale purposes, in any given year. Both the modified sinking-fund method and the straight-line method are correct accounting methods, proper to be incorporated in advance, for example, in a contract between the state and a public service corporation. But where there is no contract, and the inquiry is, as in this case, directed to a determination of the *fact of present value in a given year*, both these methods cannot be equally right. In the example in the tables, for instance, the structure would be worth at the end of the sixth year, $47,080 by the modified sinking-fund method, and $40,000 by the straight-line method.

It has been necessary to discuss at length these accounting methods, first as an introduction to a proper understanding of the problem in hand and secondly to show the palpable error of reckoning present worth and proper annual allowance purely on the basis of a cost-accounting method, without reference to actual condition and value in fact.

The problems involved in depreciation have only recently been studied and appreciated. The Spring Valley Water Company did not establish a depreciation reserve until 1908 (Exhibit 174); and this was the case generally throughout the country (7963). The Knoxville decision in January, 1909, marked the time of change in accounting practice. Prior to that, all renewals and replacements were charged to operating account—the replacement method above; the public thus paid only for matured depreciation, and nothing on account of accruing but unmatured depreciation. In this state, the decisions of the Supreme Court refused sanction to an annual allowance for depreciation reserve in San Diego Water Co. v. San Diego, 1897, 118 Cal. 556, 583, and Redlands Water Co. v Redlands, 1898, 121 Cal. 312. It is to be noted that the late Chief Justic Beatty, in a dissenting opinion, page 588, said that "an annual allowance should be made for a sinking fund" sufficient to effect replacement of depreciated plant.

It is evident, therefore, that we have before us in the case of the plaintiff, a situation where accounting practice has changed at a point part way through the life of the depreciating structures, from a replacement method, enjoined by the state court, to a method using depreciated value as the rating base, enjoined by the Supreme Court of the United States. It is thus a case where the neglect to provide in the rates charged for the accruing depreciation cannot be said to be wholly the fault of the Spring Valley Company. In any

event, under the rule of the highest court, the plaintiff has lost the unamortized depreciation in its existing structures; phrased otherwise, we must treat it as already paid, contrary to the fact. Now of the two methods of amortization where investment return is rated upon depreciated value, namely the modified sinking-fund method, and the straight-line method, the latter has been seen to involve, at any point in the plant's life, the greatest deduction for accrued depreciation of capital in structures. This is strikingly illustrated by ————'s testimony. At the master's request the witness computed accrued depreciation of the Spring Valley structures and the required annual allowance by both the modified sinking-fund and straight-line methods, reproduction cost and estimated lives being of course the same. The result was as follows (Exhibits 161, 162).

	COST NEW	ACCRUED PERCENTAGE	DEPRECIATION AMOUNT	COST DEPRECIATED	ANNUAL ALLOWANCE
Modified sinking fund method..	$25,128,930	13.9	$3,496,847	$21,632,083	$277,449
Straight line method.....	$25,128,930	31.2	$7,835,847	$17,293,847	$403,891

In other words, the plaintiff's capital must on ————'s estimates, by a change from the replacement method of cost-accounting, suffer a deduction of at least three and one-half millions, which the public ought to have paid in the past but did not. Shall that loss be increased to nearly eight millions merely by a choice of theoretical mathematical methods of amortization? *As I said in the report in the Contra Costa case, if I were to decide the question of present depreciated value by reference merely to formulas of amortization, I should on grounds of obvious justice, adopt the method which involves the lesser deduction from capital made on the ground of an assumed but fictitious payment in the past. This case only strengthens the conviction I have previously arrived at, that the straight-line method is entirely unsuitable as a basis of valuation of properties of long life.*

Note also the quotation on page 372 herein, from Judge Wright's opinion.

Fourth. The opinion on this subject set forth by Halford Erickson, formerly the able chairman of the Wisconsin Railroad Commission and now in private practice, in an address on "Depreciation and Its Relation to Fair Value," delivered before the conference of City Mayors and others interested in Public Utility Control, called by the then Commissioner of Public Works of Philadelphia, Mr. Morris L. Cooke, held in Philadelphia, November 10–13, 1915, is significant in this connection.

Much has been said about the relative merits of the straight line and sinking fund methods of providing for depreciation. Without going into details in this matter it can be said that the sinking fund method implies a more efficient use of the reserves. It also means that, because of such use, the amount the customers will have to contribute to cover depreciation is less than under the straight line method. *The inference that can be drawn from these facts is that the sinking fund method is the most economical and hence would also seem to be the best of the two methods from the point of view of public interest.*

In this connection it may be in place to repeat in substance something that has already been said. All virile and live enterprises are constantly in need of readily available funds for various more or less temporary uses. The ability to quickly obtain such funds often stands for material savings in more respects than one. For these and other reasons it may not be in line with the best policy to place too many restrictions upon the balance in the depreciation reserve.

Fifth. It is further to be noted that sinking fund methods were used as a basis for forming or determining judgment in the following of the cases cited:

a. Portland, Maine, by the engineers on both sides of the case,

b. Racine, by Hazen and by the engineers of the Wisconsin R. R. Commission,

c. Denver, by the Federal Court,

d. San Francisco, by the Master of the Federal Court,

e. Indianapolis, by the engineers to the Public Service Commission of Indiana, as well as by the Company's engineer,

f. East Chicago, by the engineers on both sides of the petition,

g. In the remainder of the examples cited by the writer, for reasons heretofore stated.

Wisconsin Water-Works Depreciation Reserves. Halford Erickson's discussion upon this subject, before a convention of the Central Water Works Association, held at Detroit, Mich., September 25, 1912, is interesting by way of comparison, indicating that for the Wisconsin properties investigated, the elapsed life of which was very much shorter, for the most part, than were those of the examples here cited in table 1, the "percentage condition" of the properties indicated by the reported depreciation reserves, amounted to approximately 91 per cent, ranging from about 95 per cent to 80 per cent in the 23 examples cited by Erickson. The corresponding accrued depreciation thus varied from 5 to 20 per cent; and the annual percentage or fund for depreciation, based upon total property including land, varied from 1.12 per cent to 2.61 per cent, averaging 1.53 per cent. The elimination of the value of the land would have had

very little effect upon these averages, as the amount of land involved in the Wisconsin water works cited is usually substantially less than 10 per cent of the combined value of land and structures.

TABLE 2

*Depreciation reserves—Wisconsin water utilities**

	POPULATION OF CITY (1910 CENSUS)	COST OF REPRODUCTION NEW	PER CENT CONDITION	PRESENT VALUE	COMPOSITE LIFE (STRAIGHT LINE)	COMPOSITE LIFE (4 PER CENT SINKING FUND)	ANNUAL FUND (STRAIGHT LINE)	PER CENT OF FUND TO TOTAL PROPERTY INCLUDING LAND
					years	*years*		
1	40,384	$690,001	94.6	$653,070	67.29	58.00	$8,548	1.24
2	25,531	531,020	93.4	496,346	49.86	44.34	8,212	1.55
3	11,594	401,581	94.0	377,517	63.11	56.25	5,642	1.41
4	16,773	268,687	84.6	227,445	51.96	47.68	4,458	1.66
5	14,610	318,327	91.5	291,022	61.62	56.95	4,784	1.50
6	8,893	185,148	92.3	170,824	67.60	59.60	2,464	1.33
7	8,692	127,897	88.4	113,060	48.11	55.74	2,325	1.82
8	5,629	109,432	94.7	100,502	60.55	53.30	....	....
9	3,739	101,360	93.1	94,319	44.76	44.16	1,145	1.13
10	7,196	84,276	90.2	77,201	60.03	55.57	1,076	1.28
11	5,036	73,493	90.1	66,216	56.99	50.65	1,163	1.58
12	3,830	61,139	92.0	56,285	66.33	58.38	812	1.33
13	2,675	36,947	92.2	34,072	55.51	51.07	577	1.56
14	2,907	36,899	90.1	33,225	59.31	51.75	518	1.40
15	2,582	49,855	92.9	46,315	54.66	48.69	748	1.50
16	1,808	23,138	89.9	20,804	69.77	62.04	286	1.24
17	1,833	11,784	79.6	9,937	36.49	37.00	288	2.44
18	804	8,115	90.6	7,334	46.40	45.75	162	2.00
19	15,125	242,327	92.0	224,483	62.90	58.12	2,901	1.20
20	13,027	220,382	92.9	204,716	66.19	58.51	2,472	1.12
21	13,894	217,611	93.1	202,579	63.69	56.21	2,784	1.28
22	18,797	309,449	90.2	279,312	53.49	46.93	8,088	2.61
23	6,324	120,816	91.7	110,426	55.16	49.33	1,839	1.52
Arithmetical average.....	10,076	$183,899	91.0	$169,435	57.55	52.43	$2,786	1.53

* From paper by Halford Erickson for the Convention of Central Water Works Association, Detroit, Mich., September 25, 1912.

Other data upon depreciation of water works structures. Of less significance than the data obtained from the complete life histories of water works properties are the results of thorough examination and estimate of depreciation of such properties, at any one time or period.

RECORD DATE GENERALLY DECEMBER 31	LOCATION	OWNER	AGE OF PLANT	POPULATION	GROSS REPRODUCTION COST OF EXISTING STRUCTURES ONLY INCLUDING OVERHEAD AND INTEREST ON PRE-WAR BASIS	GROSS ANN REVENU
			years			
	Western States					
1913	San Francisco, Cal.	Spring Valley Water Company	55	453,000	$21,537,000	$3,388,0
1914	California	Water Company	—	300,000	1,650,000	
1914	Denver, Col.	Denver Union Water Company	43	242,000	10,411,000	1,386,0
	Southern States					
1912	Texas	Water Company	35	107,000	2,136,000	390,0
1909	Knoxville, Tenn.	Knoxville Water Company		48,140	1,211,000	175,0
1910	Macon, Ga.	Macon Water, Gas and Electric Company	29	39,700	655,248	115,0
1913	Columbia, Tenn.	Columbia Water Company	29	6,700	105,633	25,0
1917	Florida	Water Company	28	56,250	913,000	209,0
	Central States					
1916	Indianapolis, Ind.	Indianapolis Water Company	45	276,000	7,435,000	1,133,
1911	Des Moines, Iowa	Des Moines Water Company	29	90,000	2,731,000	304,
1916	Indiana	Water Company	22	29,600	609,000	108,
1911	Illinois	Water Company	26	26,600	258,000	58,
1914	Pennsylvania	Water Company	31	16,000	410,000	53,
1913	Racine, Wis.	Racine Water Company	26	38,000	1,219,000	140,
1916	Dayton, O.	City Water Department		145,000	3,834,000†	278,
	Eastern States					
1912	New Jersey	Water Company	63	371,000	8,459,000	1,095,
1916	Pennsylvania	Water Company	66	340,000	10,055,000	1,114,
1911	Pennsylvania	Water Company	57	232,000	7,288,000	856,
1916	New York	Water Company	67	102,000	4,509,000	439
1916	Pennsylvania	Water Company	23	90,000	3,154,000	295,
1907	Portland, Me. et als.	Portland Water District	39	78,200	2,594,000	295
1914	Rhode Island	Water Company	36	28,837	1,656,000	210
1914	New Hampshire	Water Company	60	28,000	917,000	101
1903	Waterville, Me. et als.	Kennebec Water District	16	17,600	329,000	33
1912	Massachusetts	Water Company	28	15,600	486,000	55
1913	Bristol, Conn.	Bristol Water Company	28	14,274	444,000	44
1906	Massachusetts	Water Company	24	7,240	145,000	46
1911	Rumford Falls, Me.	Rumford Water District	18	3,410	167,000	12
1907	Livermore Falls, Me.	Livermore Water District	8	3,140	85,000	7
1906	North Conway, N. H.	North Conway Water District	23	1,690	35,000	4
Totals			(954)	(3,206,981)	(95,437,881)	(12,37
Averages			35.3	106,900	3,181,300	42
Maximum			67	453,000	21,537,000	3,38
Minimum			8	1,690	35,000	4
Normal conditions (approximate)						

* Fixed by commission as equitable.

† Valuation by S. G. Pollard brought down to date.

‡ Abnormal as City does not compensate Water Department for Fire Protection Service. Omitted from total and a

‖ Average of Plaintiff and Defendant.

TABLE 3

Depreciation of water works—structural plant only

LATION	GROSS REPRODUCTION COST OF EXISTING STRUCTURES ONLY INCLUDING OVERHEAD AND INTEREST ON PRE-WAR BASIS	GROSS ANNUAL REVENUE	ACCRUED DEPRECIATION			ANNUAL DEPRECIATION ALLO	
			On existing plant (structures)		Abandoned structures, amount	Amount	Per cent of gross reproduction cost
			Amount	Per cent			
3,000	$21,537,000	$3,388,000	$2,800,000	13.0	$3 20,000	$218,000	1.01
0,000	1,650,000					150,000	
2,000	10,411,000	1,386,000	1,321,000	12.7	1,421,000	140,000	1.34
7,000	2,136,000	390,000	440,000	20.6		40,000	1.87
8,140	1,211,000	175,000	121,000	10.0		15,000	1.24
9,700	655,248	115,000	101,120	15.4		5,580	0.85
6,700	105,633	25,000	23,600	22.3		2,200	2.08
6,250	913,000	209,000	118,000	12.9	40,000	12,000	1.31
6,000	7,435,000	1,133,000*	736,000	9.9	883,000	76,000	1.02
0,000	2,731,000	304,000	362,000	13.2		30,428	1.11
9,600	609,000	108,000	64,000	10.5	94,000	7,600	1.25
6,600	258,000	58,900	56,700	22.0		3,300	1.28
6,000	410,000	53,000	81,000	19.7		5,000	1.22
8,000	1,219,000	140,840	70,600	5.8	19,000	26 years record	0.45
5,000	3,834,000†	278,000	846,000	22.1		55,000	1.43
1,000	8,459,000	1,095,000	1,048,000	12.4		95,754	1.13
0,000	10,055,000	1,114,000	1,325,000	13.2		111,000	1.11
2,000	7,288,000	856,000	500,000	6.9		59,000	0.81
2,000	4,509,000	439,000	352,000	7.8	285,000	35,000	0.73
0,000	3,154,000	295,000	272,000	8.6	250,000	23 years record	1.29
8,200	2,594,000	295,000	498,000	19.2	137,000	39 years record	1.29
8,837	1,656,000	210,000	236,000	14.2		19,000	1.15
8,000	917,000	101,000	151,000	16.5		11,000	1.20
7,600	329,000	33,500§	47,000§	14.3		4,200	1.28
5,600	486,000	55,700	61,750	12.7		4,240	0.87
4,274	444,000	44,250	31,500	7.1		3,380	0.71
7,240	145,000	46,000	33,000	22.7		2,400	1.65
3,410	167,000	12,750	14,800	8.9		1,805	0.89
3,140	85,000	7,520	2,600	3.1		538	0.63
1,690	35,000	4,200	5,800	16.6		400	1.14
6,981)	(95,437,881)	(12,372,660)	(11,719,470)	(394.3)			(33.34)
6,900	3,181,300	426,700	404,000	**13.6**			**1.15**
3,000	21,537,000	3,388,000	2,800,000	22.7			2.08
1,690	35,000	4,200	2,600	3.1			0.45
				8–13%			**0.9–1.3**

ice. Omitted from total and average.

CIATION ALLOWANCE, EQUITABLE AMOUNT				
Per cent of gross reproduction cost	Per cent of depreciated reproduction cost	Per cent of gross annual revenue	Cents per capita	COMMENTS
1.01	1.16	6.4	48	By Federal Court Master
			50	Allen Hazen
1.34	1.54	10.1	58	By Federal Court
1.87	2.36	10.2	37	Metcalf
1.24	1.38	8.6	31	Court
0.85	1.01	6.1	18	Board of Arbitration
2.08	2.68	8.8	33	Board of Arbitration
1.31	1.51	5.8	21	Metcalf (12,550 additional population supplied wholesale omitted.)
1.02	1.13	6.7	28	Indiana Public Service Commission
1.11	1.29	10.0	34	Metcalf
1.25	1.40	7.0	26	Metcalf
1.28	1.64	5.6	12	Metcalf
1.22	1.52	9.4	31	Metcalf
0.45	0.47	6.7	15	Allen Hazen. Life History
1.43	1.84	(19.8)‡	38	
1.13	1.29	8.7	26	Metcalf
1.11	1.50	10.0	33	Metcalf
0.81	0.87	6.9	25	Metcalf
0.73	0.78	8.0	34	Metcalf
1.29	1.39	8.0	48	Life History. Metcalf.
1.29	1.46	9.6	45	Life History. Average invest. 18 years
1.15	1.34	9.1	66	Metcalf
1.20	1.44	10.9	39	Metcalf
1.28	1.49	12.5	24	
0.87	1.00	7.6	27	Metcalf
0.71	0.76	7.1	22	Metcalf
1.65	2.14	5.2	33	Metcalf
0.89	0.97	11.6	43	Metcalf
0.63	0.65	7.2	17	Metcalf
1.14	1.37	9.5	24	Metcalf
(33.34)	(39.38)	(242.4)	986	
1.15	**1.36**	**8.4**	**33**	
2.08	2.68	19.8‡	66	
0.45	0.47	5.2	12	
0.9–1.3	**1.0–1.4**	**8–12**	**35–45**	

There is shown in table 3 on "Depreciation of Water Works Structural Plant Only," the results of such examination of 28 different water works properties made by the author, and of two made by others of which he has had some knowledge. For convenience they have been assembled in four groups, covering three water works properties in the western states, five in the southern states, seven in the central states and fifteen in the eastern states.

Comments upon table 3. These records are perhaps of some confirmatory significance, having been based upon detailed examination, analysis and judgment of the author, by whom also were made a majority of the records covered by table 1.

They indicate that the accrued depreciation upon the existing structures is likely to lie within the previously stated range (8 to 13 per cent) varying in the thirty examples cited, from 3 to 23 per cent, averaging 13.6 per cent.

The range of average or fair annual depreciation allowances for normal water works structures indicated in the thirty examples cited, varies from

	Average of all records
0.9 to 1.3 per cent of gross-reproduction-cost-new	1.15 per cent
1.0 to 1.4 per cent of depreciated-reproduction-cost	1.36 per cent
8.0 to 12.0 per cent of gross-annual-revenue	8.40 per cent
35 to 50 cents per capita	33 cents

The extremely high and low values found for accrued depreciation in the examples cited, are readily accounted for by the abnormal conditions or structural problems involved.

The accrued depreciation found in the analyses summarized in table 3 have also been grouped as between pumping plants and gravity plants, with results shown in table 4.

These results indicate that within the limits of the examples cited —which cover 7 gravity plants and 21 pumping plants, the Livermore Falls record being omitted as involving too young a plant to be of significance in such a study—there appears to be no substantial difference, within the limits of the accuracy of such work, in the average percentage of accrued depreciation upon gravity and pumping plants, that for the gravity plants averaging 13.9 per cent, and for the pumping plants 14.0 per cent.

TABLE 4

Age and depreciation of pumping and gravity water works

PUMPING PLANTS

Location	Age	Depreciation
	years	*per cent*
Texas	35	20.6
Knoxville, Tenn		10.0
Macon, Ga	29	15.4
Columbia, Tenn	29	22.3
Indianapolis, Ind	45	9.9
Des Moines, Ia	29	13.2
Indiana	22	10.5
Illinois	26	22.0
Racine, Wis	26	5.8
Dayton, O		22.1
New Jersey	63	12.4
Pennsylvania	66	13.2
Pennsylvania	57	6.9
Pennsylvania	23	8.6
New York	67	7.8
Waterville, Me	16	14.3
Massachusetts	28	12.7
Rhode Island	36	14.2
New Hampshire	60	16.5
Massachusetts	24	22.7
Florida	28	12.9
Totals	709	294.0
Average	37	14.0

GRAVITY PLANTS

Location	Age	Depreciation
	years	*per cent*
San Francisco, Cal	55	13.0
Denver, Colo	43	12.7
Portland, Me	39	19.2
North Conway, N. H	23	16.6
Bristol, Conn	28	7.1
Rumford Falls	18	8.9
Pennsylvania	31	19.7
Totals	237	97.2
Average	34	13.9

SUMMARY

Number of plants	Type of plants	Average age	Average accrued depreciation on existing plant
		years	*per cent*
21	Pumping	37	14.0
7	Gravity	34	13.9
28	Combined record	36	14.0

Livermore Falls record omitted as too young (8 years) to be significant.

CONCLUSIONS SUGGESTED BY THE ANALYSIS OF THE LIFE HISTORIES OF ELEVEN WATER WORKS PLANTS AND OTHER CONFIRMATORY DATA SUBMITTED HEREIN

1. *In reviewing records of depreciation care must be taken to determine their completeness.* Many so-called depreciation records, purporting to give normal life records or expectancies for structures, are really records of plant failures based upon the experience had with the structures which failed and had to be replaced, without consideration of the life history of the remaining structures which did not fail and were still rendering good service—thus overestimating the fair or normal depreciation allowance.

On the other hand, in determining the amount of abandoned property, recollections of old employees are not alone always a safe substitute for specific records, and prudence dictates the necessity for making reasonable allowance for omissions in such cases,—lest depreciation be underestimated. Also for overhead costs frequently not charged to construction in the past.

2, *The accrued depreciation upon existing structures* involved in *old* operating water works properties, is likely under normal conditions to amount to from 8 to 13 per cent of their cost,—varying in the eleven plants cited, from about 6 to 19 per cent, and averaging 11.6 per cent—the depreciation upon the more substantially built properties having structures of more enduring character corresponding to the lower limits, and upon the plants having structures more perishable or less well maintainted, approaching the higher limits. In young properties, built a decade more or less ago the accrued depreciation upon existing structures is likely to be within two-thirds of the above stated amounts. These allowances appear reasonable in the light of the record of abandoned property found below under No. 4.

3. Vice-versa, the *operating condition of old, well-established and operating water works properties.* is likely to lie between 87 and 92 per cent of the cost new of existing structures; and between 92 and 97 per cent of *young properties* ten years, more or less, old.

4. The *abandoned structures* in the examples cited, ranged from 2 to 13 per cent, averaging 8.4 per cent, of the combined cost of the existing and abandoned structures,—indicating the fairness of the allowances cited in No. 2 above, for normal accrued depreciation upon existing structures.

5. The *total depreciation upon existing plus abandoned structures* ranged in the examples cited, from about 7 to 26 per cent, averaging 19 per cent, of their cost new; and as based *upon the net or depreciated cost of the existing structures only*, from about 8 to 30 per cent and averaging 21 per cent, depending upon the character of the plants.

6. The fair average annual depreciation, expressed in different terms, is perhaps the most significant and helpful measure, and should normally lie within the following limits:

a. The average annual depreciation upon the gross reproduction cost of the existing structures of normal water works properties, is likely tc lie between 0.9 and 1.3 per cent of their cost new, the average of the

eleven examples cited being 1.17 per cent, the smaller percentage corresponding to the properties having structures of enduring character, such as large storage reservoirs, built of earth, masonry conduits, supply conduits and cast iron distribution systems of pipe of ample dimensions; the larger amount corresponding to plants having structures relatively more perishable, such as reinforced masonry dams, wooden supply pipes, pumping stations, filter plants and supply mains of less generous proportions.

b. The average annual depreciation upon the depreciated cost of the existing structures of normal water works properties, is likely to lie between 1.0 and 1.4 per cent of their cost new, the average of the cases cited being 1.3 per cent, the variation being due to the factors cited above.

c. The average annual depreciation in percentage of gross annual revenue of normal water works plants, is likely to lie between 8 and 12 per cent, being dependent upon the character of the structures, the range in the eleven examples cited being from 7 to 20 per cent, averaging 10.5 per cent. While this basis of determining depreciation is not an absolute one, within the range of normal earnings, it is an exceedingly useful check upon other methods of computation, and it is an easy and advantageous method of accounting depreciation when controlled by periodic detailed analysis of structural depreciation. It is likely that this method of allowing for depreciation will come into more general use with a lapse of time and accumulation of reliable data.

d. The average annual depreciation per capita in normal water works properties is likely to be between 40 and 50 cents, ranging from 15 to 89 cents, and averaging 45 cents in the eleven cases cited. The extremely low and high values are abnormal ones, as appears from the detailed discussion upon them. In theory the per capita unit is based upon the existence of a more or less normal type of water works, the gravity plants generally involving greater cost of structures but lower rate of depreciation than the pumping plants.

This basis of comparison (d) is to be used as a means of checking other methods of computation, rather than as a direct means of determining fair annual depreciation allowance.

7. *The range from normal results* may be considerable in special cases, as appears from some of the examples cited in table 1, but full knowledge of the relative local situation and character of plant, and careful investigation of its actual structural condition, will mate-

rially reduce the difficulty of using normal-type results as a basis for determining reasonable allowances for accrued and annual depreciation for more or less abnormal cases.

8. *Experience in determining the accrued depreciation upon old water works properties has shown that the application of the straight line formula gives excessive results, clearly at variance with the observed condition of the structures.* The results obtained from the sinking-fund, compound-interest, or equal-annual-payment methods, are much more normal.

In short lived property, or comparatively new structures, the results differ less markedly. In any event, the condition of the structures should be carefully observed, and the results obtained by application of any formula or method for determining depreciation, should be checked by and made to accord with the observed condition of the structures and weight should be given to such carefully observed precedent as may be available with respect to accrued depreciation upon and life histories of old water works, such as those reported herein.

By degrees experience will crystallize in more direct allowance and limitations under observed conditions, independent of formulas.

9. *The unfairness of arbitrary application of accounting methods for determining accrued depreciation,* has been clearly set forth herein in the discussion upon Reasons for Use of Sinking Fund Methods for Determining Accrued Depreciation (p. 383) and in the quotations from the opinion of Judge H. M. Wright, Standing Master in Chancery of the Federal Court of the District of Northern California, in Spring Valley Water Company v. City and County of San Francisco, Cal. (1916), pages 372 and 384.

THE TREND OF PRICES[1]

By D. F. O'Brien

There has been a good deal of debate amongst American business men as to what they might attribute the cause of the halt in the resumption of business. About ninety days ago the National Association of Manufacturers sent to its members a questionnaire asking for their individual opinions as to what they considered to be the real cause of this failure to get under way. If that questionnaire did no other good it served at least to bring out the fact that there was considerable independence of thought amongst American business men, because there were just as many different view-points as there were answers to the questionnaire.

Now within the last thirty days things are changing; there is a crystallization of thought; it is slowly dawning on the minds of business men that perhaps the chief impediment to the normal resumption of business is the waiting attitude of the purchasers, beginning with the National Government itself and so on down to the smallest dealer in the smallest towns. The idea prevails that if they can only wait long enough, if they are not lucky enough to be able to replenish their depleted stock at war prices, they will at least be able to get their goods at a considerable discount from the prevailing level of prices.

Now we have as opposed to that the view-point of the economist. Those of them who favor the quantitative theory of money say that the general level of prices is dependent upon the relation which exists between the volume of the circulating medium and the rapidity of its turn-over and the total volume of business to be transacted thereby. That is to say, if we take a certain number of dollars that are circulating by cash and by check, and if we double that number and still maintain the amount of goods and the services which we render therefor, the natural result is that prices double. And they go on to show that every great change in price levels throughout history has that cause back of it. They point to the sixteenth century revolu-

[1] Informal address at the Buffalo Convention, June 11, 1919.

tion in prices, and they say that that was attributable to the influx of gold and silver from the mines of the New World. They further point to something that is within the recollection of us all, the period from 1896 to 1916 following the discovery of gold in South Africa, Cripple Creek, the Klondike, and other sources from which there has been poured into the world's supply of gold perhaps an additional $8,000,000,000. We all know that following that addition to our gold supply there was a permanently higher level of prices which they say is attributable to that and only to that cause.

Now since the opening of the war there has been added about $35,000,000,000 to the paper money of the principal trading countries of the world. To this there has also been added by the warring countries over $175,000,000,000 of bonds. With such an enormous amount of credit back of us, they argue that there can be no question of doubt that we are on a permanently higher level of prices which is due to the same causes as all of the great changes in price levels that have taken place in the past.

The argument is sometimes made: "Why, this is only temporary, it cannot be permanent." It is true that no one will deny that we will see temporary fluctuations of prices in isolated cases; but these fluctuations mean nothing so far as the general level goes, any more than the height of the different waves of the ocean in any way affects the height of the tide. The tide level remains the same.

Now we may not be able to follow the economists in such arguments, but as common sense men who have to grapple with facts daily, we can readily get at it from another standpoint. Let us consider the cost of the principal articles entering into our business. We realize that our costs are made up chiefly of perhaps four important items. The first and most important of these is labor; then raw materials, the cost of transportation, and the cost of distribution. Taking up the first of these items and examining it as to what are the chances of lower labor costs. Prior to the war the extraordinary opportunities offered by this Land of the Free brought to our shores annually some 1,200,000 workers, the brain and brawn of the world. In 1914, that incoming stream was interruped. In the latter half of that year we lost perhaps one-half million men. While the war was in progress there was pactically no immigration. Since the opening of this year we are losing men from our eastern ports as fast as passports can be made out for them. We will lose possibly in the first six months of this year a half million men in that way.

To this must be added five years of lost immigration, from 1914 to 1919, at the rate of 1,200,000 a year, so that we have a 7,000,000 shortage in the normal supply of labor of the country, which comprises 20 per cent of our effective male workers. With this reduced supply we are up against the problem of taking care of the normal growth of the country and of making good the dammed up demand of the last two years. In addition to that we have to take care of our foreign trade, which is going to be triple what it would have been under normal conditions, due to the existence of the war.

Now what is the result? There are none of you who are not fully aware of what the result will be. Why, today, with even this waiting program in existence and with the manufacturers not making over 60 or 70 per cent of their normal output, still there is no industrial center in this country today that is not short of skilled workers. In the city of Detroit alone, that shortage is upwards of 30,000 men. As illustrative of conditions in the cities along the Eastern seaboard; 60 to 90 days ago when the foundry business was nearly at a standstill, the moulders made a demand for a change from the prevailing 9 hour day at 60 cents per hour, to an 8 hour day at 75 cents per hour. The manufacturers were in an ideal condition for a fight; there was so little to be done they could afford to shut down and thus bring them to terms—Did they do it?

They profited by their experience during the war and before making a decision investigated labor conditions and found such a general shortage that they felt if the men moved out of their district they would be unable to replace them later. They paid the advance. Those of you who will take the time to study the problem will realize that they had to pay it, that wages are not coming down, but, if anything, they are going up. And what is true of skilled labor is probably true in far greater measure of unskilled labor. All over the country there is a shortage, with perhaps the exception of New York and Pittsburg. In New York, owing to the mustering out of a number of western regiments, they have an overplus there, but that means nothing; they will not work. When they come back and learn of the high prices prevailing here during the war, they want to get some of the good things and they will not work for less than 55 cents an hour for common labor.

Now we pass on to the second item of cost, materials. When you come to consider it, all raw materials, whether they are the product of the mine, or the forest, or of the soil, have entering into them the

item of labor; so that we may consider that here again is something that we cannot look for lower costs on.

As to the next item of transportation, enough said. You have seen the reports from the Government of the daily increase in the cost of transportation and the fact that were it not for politics the rates today would be higher rather than lower.

There is only one item left, that of distribution. Now the speaker holds no brief for the jobber or for the retailer. Their halting attitude today is blamable in the extreme. Salesmen going out through the country will tell you on their return that men who formerly ordered in thousands are today ordering in hundreds, and they will tell the salesmen that it is only as a matter of courtesy to him that they are giving such an order, that it is a favor. But before the salesman leaves they will take him one side and suggest: "Now this is only a little order, it is hardly worth while bothering to make it up, but if you have it in stock, for God's sake ship it to me quickly." In other words, their shelves are bare. The shelves of the country are bare. So that when we take up the items individually or collectively, we can see, as practical men examining it from this practical standpoint, that we will reach the same conclusions as the economists do who view it from the other standpoint. Now it is vital that we should all realize that we are up against new conditions; it is vital that we understand the manufacturers' problems that are staring him in the face in the immediate future.

Never except during the world war has any nation been called upon to face such a problem. We have all of our own demands to meet, all of our normal growth to take care of, and at the same time we are called upon to rebuild the world. Gentlemen, the quicker we realize that fact the quicker will be our resumption of progress along the path of prosperity.

THE TREND OF PRICES[1]

By Charles R. Wood

At the request of the Publication Committee, the speaker undertook to secure from a number of persons with opportunities for viewing market conditions in a broad way, their opinions of the subject which has been introduced so ably by Mr. O'Brien. From the comments and suggestions gathered in this manner, I wish to bring before you the views which seem to best supplement the statements to which you have just listened. The first is from Paul A. Ivy, general sales manager of the American Cast Iron Pipe Company, the second is from the president of one of the largest cement making companies in the country, who declines to allow his name to be given, and the third is from W. W. Macon, one of the editors of the *Iron Age*. A fourth, by Edgar J. Buttenheim, president of *The American City*, will be read by the writer.

P. A. Ivy: Since the signing of the armistice, November 11, 1918, the price question has been a big problem; not so much high prices, as the uncertainty of a stable market and, as a consequence, the "watchful waiting" policy has been largely adhered to.

When the Industrial Board was appointed by the Secretary of Commerce through the efforts of the United States Chamber of Commerce, this seemed to have a stimulating influence. Inquiry was much better and there was an improvement in sales, but the refusal of the Railroad Administration to recognize this board absolutely stopped buying until the result of the controversy was known. With the dissolution of the Industrial Board, the natural forces of supply and demand are now left to adjust prices from war levels to those of peace. Unfortunately, the public is not yet willing to think in terms of present production cost rather than the pre-war basis of finished materials. Present prices can in no way be compared with pre-war figures. If we are going to use the dollar as a basis of comparison, we must for-

[1]Read before the Buffalo Convention, June 11, 1919.

get the value placed upon it prior to the war and think of it only in terms of what it will buy.

As an illustration, if we were selling pipe in Kansas, the principal income of which is from wheat, we should speak of pipe selling not for so many dollars per ton, but rather for so many bushels of wheat per ton. The public must take this view of present market conditions, if they are to have a fair idea of values of any commodity. By the same token, the Kansas farmer is not to be told that he is getting $2.70 per bushel for wheat today, as compared with $1 before the war, but rather it is to be figured that today it takes, we will say, 70 per cent of his production to pay for labor, farming machinery, etc., whereas before the war, 60 per cent of his production paid for the same thing.

Again, municipalities should not consider the difference in cost per ton of the pipe, but the difference in cents per foot of the pipe laid in the ground and its work in increasing the value of the property on the streets through which it has been laid. The discontinuance of improvements in vacant land causes loss in interest and taxes far in excess of any possible difference in the value of the cast iron pipe laid in the trench.

While the pipe industry of the country is not operating to capacity, coöperation on the part of municipalities and all other large users of cast iron pipe would, within a short time, create a demand that would permit maximum production at minimum operating costs. It does not take a Solomon to tell you it makes a great deal of difference in the cost per unit of production, whether the plant is running full or part time, but the manufacturer is not any more willing to gamble on the market than the buying public and right here comes in the importance of pulling together. As the war called for coöperation of all, so the adjustment to new peace conditions calls for the same unusual coöperation. To enable the manufacturer to operate economically, the slogan of the municipality, the public utility, and other buyers, should be to go ahead with needed improvements.

There have been few water or gas installations for the past two years or longer, and extension work has been held up for a like period, except in emergency cases. We, therefore, are safe in assuming that actual existing requirements for home consumption would tax the pipe foundries of this country to their utmost capacities for a long period.

Furthermore, we have every reason to believe that American manu-

facturers have greater opportunities in foreign fields than ever before. For a time, at least, South America must look to us for its requirements and the same is true of the Far East. They cannot draw their supplies from Europe, because so far as Continental Europe is concerned, the seat of the pipe industry, especially Belgium, was in the midst of the fighting area, which means that the foundries must be rebuilt. The English foundries will be taxed to take care of domestic demands, but should they have any surplus, Continental Europe will certainly absorb it until they get their foundries to going. There probably never was a time in the history of the industry when stocks at the pipe shops in the United States were as low as they are today, and the probabilities are that the law of supply and demand will be a big factor in the immediate future. Close coöperation between the buyer and the manufacturer, backed up by a little faith on the part of both in each other, is what we need. Indeed the outlook for business in this industry is good, but the country is suffering from a severe case of "cold feet," caused by ungrounded fears. "Cold feet" seems to be a spasmodic affliction of business and we lack courage to go ahead.

A CEMENT MANUFACTURER: Cement prices at the present time seem very high. In the East and Middle West they have declined somewhat since the signing of the armistice. The writer's belief is that there is likely to be a tendency toward still lower prices. It is, however, quite out of the question to expect any very large decline in the immediate future, and it is safe to say that cement prices will never again be as low as before the European war.

During the last two years, in 1918 especially, the building industries in this country were very seriously affected by war conditions indirectly and by Government action directly, so that while prices were on a high level, the volume of business was so restricted as to make the cement industry unprofitable, many companies not only making no profit but incurring large actual losses. Up to the present time there has not yet been sufficient recovery of normal conditions to give the manufacturers of cement anything like a normal volume of business. For this reason profits are very small.

The political economists, notably Fisher,[2] Holden and Moulton, have clearly presented data which should convince anyone making a

[2] See JOURNAL, June, 1919, p. 323.

careful study of present conditions that prices are likely to remain permanently at their present level, for if there is a decline, this decline will be comparatively small. High prices as they are called, are not local, they are world wide and apply to all commodities. Fundamentally these prices have been brought about by the inflation of circulation throughout the world, the high cost of living and high wages. These facts make the cost of raw material, including fuel, high, and while some of the items in the cost of living may decline within the next year or two, others, more particularly rent and housing expenses, are likely to advance.

W. W. MACON: If the writer were a custodian of public funds and sat on some board considering the authorization of, say, municipal construction work, he would be inclined to favor the expenditure at this time. He would be backed by a large part of the public and certainly by the Government at Washington as a whole, as everywhere stress is put on minimizing or preventing unemployment.

The business world has had an unusual spectacle at Washington. The Department of Labor, has been flooding the country with literature all intended to encourage construction work and thus very directly to keep everybody employed. As a part of its propaganda, it has given widespread circulation to different addresses by prominent men of the country to the effect that high prices are to remain with us more or less indefinitely; conspicuous in this literature has been the talk by Prof. Irving Fisher before the meeting of governors and mayors at the White House. In contrast with this department, which has been arguing for the stability of present prices, has stood the Department of Commerce with a plan to bring producers together to secure a new and presumably lower set of prices, thus to convince the buying public that the best possible prices are those resulting from the conferences. A third department, namely the Railroad Administration, disagrees with the Department of Labor that prices are on an indefinitely high level and even has refused to accept the lower prices through the action of the Department of Commerce. By its refusal it intimates to the country that lower prices are still obtainable in the immediate future.

The Railroad Administration seems to be of the opinion that business should be conducted in the usual way with the free play of all the factors influencing prices, but has overlooked two things, in the opinion of producers as a class. So long as the Government empha-

sizes that wage rates must not be touched (and a large percentage of the public is of the same opinion), one of the main elements in price readjustment is fixed. The other factor is that there has been an unexpectedly prolonged disinclination on the part of the whole world to go in heavily for trading, so great apparently has been the shock of the transition from a war to a peace basis and so much does the result of the peace deliberations at Paris affect world business activity.

Business was on a healthy upturn when the Department of Commerce secured Presidential approval of the plan of stabilizing prices, so-called. Then activity dropped off sharply and had shown no great signs of being renewed even when the Railroad Administration threw a bolt into the machinery. Meanwhile iron and steel producers are holding closely to the price reductions to which they agreed on March 20 at the conferences with the Industrial Board.

At the present time (April 30, 1919) there are signs of weakening, but concessions here and there, amounting to $1 per ton, do not point as yet to sharp cuts. Should a wide buying movement develop say in July, after some incidental cuts, as seems likely, it is believable that it will amount to such proportions that by the end of the year prices will be strong even should there be reductions in living costs and a general readjustment which would otherwise be reflected in a lower selling price of iron and steel commodities.

In conclusion, it seems clear that if some of the cost elements must not be reduced because of the Government attitude or public opinion, prices cannot be materially lowered. Somebody must pay the bills. To sell under costs cuts out profit taxes to the Government. It would have been well for the Railroad Administration to recognize the desirability of encouraging a return to peace time activities, though the conditions may seem partly artificial. Its widely heralded decision not to coöperate has kept the neutral world from our markets except for necessary food products. The United States has a moral obligation to the nations with which it was associated in the war not to attempt to take undue advantage of its healthier economic position. It can still liquidate its war price levels of wages quicker than they can abroad, but it may best be made a matter of months or years rather than days.

THE TREND OF BUSINESS AND PRICES IN THE WATER WORKS FIELD[1]

By Edgar J. Buttenheim

It certainly is a troublesome matter to arrive at any general consensus of opinion on the subject of business prospects and price maintenance. But the gist of the matter, as the author sees it after using up considerable mileage during the past few months and talking with officials and manufacturers in various parts of the country, is about as follows:

There are all kinds and quantities of prospective work in sight in the water works field, along the line of new installations to be made and improvements under way, etc., but the trouble is there is entirely too much hesitation and disposition on the part of the buyers to "wait a little longer" in the hope that next week or next month, or the next month after that, there will be a worth-while price reduction.

Of course, it is reasonable to expect that reductions may be made in certain commodities, but do not make the mistake of judging the whole situation from one particular instance which you have in mind. Do not say, as one municipal official did, that because he was able to buy asphalt and road oil at pre-war prices, he was going to recommend that the city wait to make its purchases of pipe, valves, pumps and water meters until prices in these lines should come down to their old level. That particular city official has a long wait coming to him. When you find prices taking a marked downward course in any line, under the present circumstances, you are likely to find it a line of goods in which labor costs are not a big item of production. In the manufacture of water works machinery and supplies, on the other hand, with labor costs figuring from 75 to 95 per cent, there is not much opportunity for any considerable lowering of prices, unless skilled labor accepts a decided wage cut, of which there is no special indication at present.

What we must all do, if we desire to see industry back on a business-like basis, is to look the situation squarely in the face and realize that

[1] Read before the Buffalo Convention June 11, 1919.

we are definitely on the basis of a new price level, and that the old price schedules on most lines have passed into ancient history as definitely and generally as the horse car. The fact that you used to buy milk for 4 cents a quart and could get good shoes for $3.50 per pair is a historical fact, but it has no more bearing on present day conditions than the size of your present hat bears to the size of the one you wore when you were five years old. That little hat used to go around your head, but it won't now, and that is all there is to it; nothing is to be gained by wishing it would still fit you.

As soon as this new basis of values is universally accepted, business will pick up and prosperity will be general, but as long as the majority of the people are playing the waiting game on their purchases, general prosperity will not come. "Buy what is needed and buy now," is the only sensible slogan.

Keeping in touch with the manufacturers and consulting engineers in the water works field, as well as with some of the municipal and water works officials themselves, the author feels fully justified in stating there is every reason why we should all feel sensibly optimistic at the present time. In support of this statement, he will quote a few comments made to him recently by some of the large manufacturers and important consulting engineers in the water works field who have to keep their fingers constantly on the pulse of the situation.

One manufacturer whom you all know sums up the matter as follows:

> From our outlook in the water works field, the volume of business is rapidly growing each day. Improvements that have been held back for the last two years as well as new prospects are being rapidly pushed forward. Up to the present time the volume of business that has been placed in our particular line has been small, but the prospects seem to be growing brighter daily.
>
> Nevertheless, the actual benefit will only begin to be arrived at towards the end of the year, by reason of the fact that after reaching determination to proceed, many cities have had to prepare their plans and specifications, which as you know, will consume anywhere from two to three months or more, depending upon the magnitude of the contemplated work. This means a number of contracts coming through so late in the season that much of the work will carry over into next year.
>
> In regard to the likelihood of prices remaining on the present basis, there seems to me little reason to expect any material decline for a considerable period of time. There may be some slight additional fall in prices, but if so, it seems to me that they will recover very quickly by reason of the fact that as soon as industries get into full swing, there is going to be as great a short-

age of labor in all probability, as there was a year or more ago. This in itself is bound to keep prices up, and the prospects for its continuance over a long period seems to me very considerable.

Some industries, of course, are picking up more rapidly than others, but in one particular city that we happen to be doing work in and have been doing work in during the entire war period, labor is today scarcer and higher paid than at any period during the war, although immediately after the armistice was declared there was for two or three months a considerable surplus, and ordinary common labor could be secured at 20 to 25 per cent less than during the war period. At the present time in this same locality labor is from 15 to 20 per cent higher than during the same period. This particular city is an automobile center entirely, but should all other lines of industry recover in anything like a normal proportion, labor will command the situation.

A consulting engineer in the West reports increasing activities in this way:

After an experience of over twenty years in water works matters, we find that there is more actual construction work in progress and more prospective work in view now than at any time in this twenty year period. Municipalities have held off extensions and improvements for various reasons, until many water works plants are in such condition that enlargements, rehabilitation and repairs are absolutely essential and necessary, and these jobs are now going ahead; and in addition to these, there are new projects that have been holding off for a few years because of war conditions, high prices, scarcity of labor, etc. We find the unusual condition of having to reply to letters every day declining engagements that a few years ago would have been very attractive. With us it is unnecessary to do anything to stimulate business, but it is merely a question of being able to handle the more important engagements and take care of work where we made preliminary estimates and reports a few years ago. The writer can recall that twenty years ago there was one water works plant built in the state of Missouri and two built in the state of Kansas, and we are safe in saying that now there are at least thirty new projects under construction in Kansas and about the same number in Missouri; and besides the projects under construction a much larger number are contemplating improvements. Our work extends over most of the states from the Mississippi westward, and we find this condition exists in nearly all of the states.

One man who has been a close student of the pipe situation for years says:

For the past four years the production of cast iron pipe has been considerably below normal; last year it was approximately 250,000 tons, or one-third of the normal average for ten years. During the first three months of this year, production reached only 50,000 tons, or approximately one-fourth of normal. Since the first of April, there has been some increase in inquiry, but actual sales have not come up to expectations.

"We appreciate of course, that the memory of $20 a ton cast iron pipe is fresh in the minds of many buyers, and their natural tendency is to hesitate in expectation of an early return to something nearer this price level than at present obtains, but to this expectation we have no reply, except that in the future, as in the past, the cast iron pipe industry will be governed altogether by general economic conditions. The advance in labor has affected the "spread" on cast iron pipe more seriously than any other metal product, (by "spread" I mean the margin between the cost of pig iron and the selling price of the pipe) this for the reason that there is no other foundry product produced in such large tonnage where manual labor is such a large factor. This is a very important point in considering the question of the likelihood of prices remaining on their present basis.

According to my figures, there is vitally needed approximately 2,000,000 tons of cast iron pipe to bring the water systems of our cities and towns up to their needed efficiency, and this tonnage, added to the normal demand, cannot be produced by the plants now in existence.

One experienced water works engineer puts it like this:

So far as this office is concerned, we have prepared more plans during the past six months than ever before, but there seems to be a tendency on the part of some municipalities to delay construction work until there is a substantial lowering of prices. This was more marked a month or six weeks ago than at the present time. Just at present there is a tendency to go ahead with new work, as officials are apparently realizing that prices are not to be reduced materially for many months or possibly years to come. Any reduction in prices must be a gradual one, and it is doubtful if the proposed work for which plans have been prepared can wait for any appreciable lowering of prices. The indications at the present moment are that in the next few months there will be a marked increase in water works construction.

On the other hand, and lest you should think the author is only selecting favorable comments, he will admit that once in a while you meet a man who cannot yet see the light ahead. For instance, one manufacturer says:

The present conditions, from our point of view, may be somewhat colloquially, but at the same time expressively, classed as "rotten," and the outlook for the future kaleidoscopic. Anyone who can correctly interpret the handwriting on the wall and forecast the future, is some wizard and entitled to make a million. We do not find ourselves in that class.

Here and there you find an engineer who thinks that the waiting game is a wise one, as shown by this communication:

I get the impression from association with owners of water works and engineers that there is a strong tendency to curtail future expenditures as much as possible while prices remain at their high level. Some of the companies with

which I am associated have a program of nearly $1,000,000 expenditure that should be completed within a year from date, but this will undoubtedly be delayed on account of high prices and difficulty of financing.

As a contrast to this, another equally brainy engineer says:

In my opinion the public is rapidly becoming convinced that comparatively high prices for both labor and material will continue for a considerable number of years to come, and consequently the expected activity may be seen soon in water works contruction.

Here is a manufacturer who feels fairly cheerful. He says:

The months of January and February this year were rather quiet. Business began to pick up in February and through February, March, April and May there was a good volume of business booked. Taken as a whole, I am of the opinion that the year 1919 will be a very good one, as far as this company is concerned.

Another manufacturer thinks greater efficiency is necessary. He says:

We can see no encouragement as to price reduction for some time to come, for while some materials have come down, the cost of labor has not, thereby making the cost of the finished product just as much and possibly more than under war conditions. Relief in that direction, in our opinion, will only come when the manufacturers throughout the country have been given an opportunity to reorganize their forces (which were mostly shot to pieces during the war) in such manner as to increase production. In other words, to get back to pre-war conditions, the volume of business must be double or treble in order to produce the same results as were formerly enjoyed under normal conditions.

Here is a man who puts it up to Washington:

My opinion is that if Congress gets together soon and passes the necessary legislation which the country is awaiting, that by the end of July, or early in August, the water works field will receive a big boom and business should be at that time at its best. Regarding prices: Material, I believe, has gone as low as it is possible to go with the present labor conditions prevailing.

This man does not look for prices to come down in two years:

Orders for water works material have been very slow to date this year, although we are anticipating an unusual volume before the year is out. To our mind, there can be no material reduction in prices this year and possibly none next year, and the sooner everyone recognizes this fact, the better it will be for all concerned.

One of the big dealers in water works supplies gives his opinion as follows:

> I cannot see how, after investigation of existing data on the situation, one can be anything but optimistic as to the future as far as the building of new water works and the extension of present systems is concerned.
>
> Since 1914 there has been practically no building or extension of water works. For the last three years, particularly, there has been almost nothing done along this line. The country is exceptionally rich at the present time. When a town has money and hasn't water, it is going to get it. This will require a great many new water works in small towns. Farming communities will be particularly well off this year, and there will undoubtedly be a lot of water works construction through the West and South.
>
> In places where water works are already installed, there have been no extensions to speak of, in spite of the fact that the population has kept increasing. The demand for extensions is there and the wealth is there, so the water supply systems *must* be enlarged. We personally expect three or four years of more water works business than the manufacturers will be able to handle.

The foregoing statements may be considered as fairly representative of the best opinion in the water works industry and the author believes that we can feel certain of two things; that the manufacturers in the water works field are going to be very busy, and that prices in general are going to remain on the new level

THE OPERATION OF AN AMERICAN OR RAPID WATER FILTRATION PLANT FOR TWENTY YEARS AT ELMIRA, NEW YORK

By James M. Caird

Elmira, New York, has a population of about 45,000. It is located in the southwestern part of the State, on the Chemung River, a few miles from the Pennsylvania line. The greater part of the city's water supply is obtained from the Chemung River, which is formed by the uniting of the Tioga and Cohoctan Rivers, 19 miles from Elmira. The Chemung River is about 50 miles in length, and flows into the north branch of the Susquehanna River. The area drained above Elmira by the Chemung River and its tributaries is about 2050 square miles. The river is subject to severe floods, the water at times rising 18 feet.

On examining the polluting territory of the river for a distance of 50 miles above Elmira, there will be found over 75,000 people in cities and villages having direct sewage connection with the river. The water always contains a marked turbidity and color and carries heavy suspended matter.

At Elmira the water for filtration is taken from the river through cribs connected with a gallery, from which it flows by gravity to the pumps.

The pumping station is equipped with electric and steam driven turbine pumps, by which the water is lifted 118 feet for delivery and forced through a 20-inch main to the filtration plant, which is about 2 miles north of the pumping station. There is an auxiliary supply obtained from an impounding reservoir on the upper portion of Hoffman Creek, about $\frac{1}{2}$ mile north of the filter plant. The water from this reservoir, when in use, flows by gravity to the filters. The impounding reservoir, was formed by the construction of a dam during 1870. It has a drainage area of about $4\frac{1}{2}$ square miles, covers 38 acres and had a capacity of 113,000,000 gallons. A recent survey, however, shows that the capacity has been reduced to 90,000,000 gallons because of material washed in at the upper end.

This reduction of 20 per cent in capacity also reduces the time for natural sedimentation. The supply for this reservoir is derived from springs and the small Hoffman Creek.

At the time this reservoir was constructed, the timber and surface soil were removed from the district to be flooded. The water from this reservoir has given trouble at all seasons of the year, because of the disagreeable odor and taste produced by algae growths. To overcome these conditions the reservoir has been drained and cleaned several times, the last time being in 1889.

In 1904 copper sulphate was applied to the water in this reservoir for the first time, the result being so satisfactory that the treatment is applied whenever there are any signs of an excessive growth of algae. The copper sulphate applications have resulted in a great saving in the cost of operating the filters as well as in removing the cause of the disagreeable odors and taste. It was found that after the water had been treated the period between washing filters increased at least three hours, while the water required for washing filters was reduced from 2.3 to 1.9 per cent. As filtered water is used in washing the filters and has to be pumped, there is considerable saving in the operating cost. The bacterial content of the water, after the copper sulphate treatment, increases greatly.

Following an epidemic of typhoid fever in 1896, an American, rapid or mechanical filtration plant was installed in 1897, but owing to some litigation no coagulants were used until March, 1898. This plant is so located that the waters from the river or the storage reservoir are filtered before being delivered to consumers.

The original filter plant consisted of 18 subsidence gravity filters, each $13\frac{1}{2}$ feet in outside diameter. In 1904 the capacity was increased by the addition of three units, so that the present plant consists of 21 units, each with an effective filtering surface of 113 square feet, or a total of 2373 square feet, which is about one-twentieth of an acre. The rated capacity of the plant is 7,000,000 gallons per day and under favorable conditions this rate has been greatly exceeded.

The process of filtration is as follows: The water to be filtered is first treated with a solution of sulphate of alumina, after which liquid chlorine is added. Originally the sulphate of alumina solution was pumped into the water before it entered the building, but this method proved to be unsatisfactory because of the variation of the steam pressure and the constant repairing of the chemical pump. In 1900

a gravity orifice feed was installed and proved very satisfactory. The sulphate of alumina was dissolved in two solution tanks having a capacity of 1700 gallons each; from the tanks the solution was pumped to the distributing tank which was placed at the top of the filter building; from this it flowed to the orifice box and then to the supply main. The excess amount of solution pumped returned to the storage tanks and kept them well mixed. The amount of solution applied to the water was governed by weir rings, and while this method produced good results in controlling the applied solution, the fact that it was necessary to pump the solution to the distributing box was a source of trouble and expense.

When the plant was enlarged, a chemical tower was constructed, thus obviating the necessity of pumping any of the sulphate of alumina or other solutions. The solutions are now applied through standard orifice feed boxes. The orifice box is so equipped with an electrical device that if the head over the orifice varies $\frac{1}{2}$ inch, a bell calls the operator to adjust it.

The solution of sulphate of alumina is prepared by weight. It has been found that a strong solution will react more quickly and better than a weak one. The solution in the storage tanks is agitated by air, the power for operating the air pump being obtained from a water wheel which is located in the filtered water flume. Repeated tests show that the specific gravity of the solution is the same at the top and bottom of the dissolving tanks.

The sulphate of alumina is purchased under specifications, the requirements being as follows:

	per cent
Alumina (Al_2O_3) not less than	17.50
Acid (SO_3) not more than	37.50
Iron, total as (Fe_2O_3) not more than	0.40
Water (H_2O) not more than	47.00
Insoluble, not more than	0.25

It is understood that if the alumina (Al_2O_3) is over 17.5 per cent the acid (SO_3) may be increased in proportion. If the results of the analyses show the alumina to be below 17.5 per cent and above 17 per cent a deduction of 8 cents per 100 pounds is made. If the alumina is below 17 per cent and above 16.5 per cent a deduction of 15 cents per 100 pounds is made. For each 0.25 per cent or fraction thereof of iron (Fe_2O_3) above 0.40 per cent a deduction of 5 cents per 100 pounds is made. The sulphate of alumina shall not contain any free acid.

The maximum amount of sulphate of alumina used was 5 grains per gallon, while the minimum was 0.25 grain, and the average for the past twenty years is 1.29 grains per gallon, or about 185 pounds per million gallons of water.

The average amount of sulphate of alumina used during the 12 years before hypo-chlorite or liquid chlorine was used was 1.45 grains per gallon, while during the 8 years in which the sterilizing reagents have been used the average was 1.04 grains per gallon, showing a saving of 28.3 per cent.

The minimum amount of sulphate of alumina which will form any coagulation is about 0.33 grain per gallon; if less is used no coagulation is visible.

The large sulphate of alumina tanks are equipped with recording gauges, which indicate at all times the amount of chemical being applied.

At times, owing to a deficiency in the alkalinity of the unfiltered water, it has been necessary to add a small amount of lime or soda-ash. This is applied by gravity to the unfiltered water.

At times it has been necessary to add an alkali to the unfiltered water, although it contained an alkalinity of about 20 parts per million by both the methyl orange and erythrosine methods. This has been termed a "dead alkalinity" because it would not coagulate the sulphate of alumina.

When lime or soda-ash is used it is impossible to obtain a filtrate absolutely free from color.

Experiments have been made using sulphate of iron and lime as the coagulant, but this method failed to give results which were satisfactory.

Late in 1909 calcium hypo-chlorite was used. This solution was applied by gravity. In 1916 this method was replaced by liquid chlorine. The sterilizing solutions are added to the water before filtration and the results have been very satisfactory. While it may require a slight additional amount of gas over that required if it was added to the filtered water, it is possible to get a better mix and a longer period of contact by applying it to the unfiltered water and it also has the advantage that it prevents bacterial growths in the sand beds.

After treatment with sulphate of alumina and liquid chlorine the water passes to the subsidence basin under each filter, and is there retained from twenty to thirty minutes. In passing through the

subsidence basin about 30 per cent of the suspended matter is removed.

The water then passes to the top of the sand. After passing through the sand it is discharged into a flume which conducts it to the first filtered water reservoir.

The filter beds are about 48 inches in depth and have 9 inches of graded gravel over the strainers. The sand in the original filters came from Red Wing, Minnesota, but the sand for the new filters came from New Jersey. Sand to replace that lost during washing has been obtained from both of these places. The mechanical analyses of the sand show it to have an effective size of 0.56 mm., and a uniformity coefficient of 1.43.

In washing the filters about 7 gallons per square foot of surface per minute are used and at the same time the mechanical rakes are operated. The average amount of wash water during the past 18 years was 2.78 per cent of the water filtered. A filter is out of operation about six minutes per wash.

About $\frac{1}{2}$ inch of sand is lost from the surface of the beds each year during washing. The lost sand is replaced every four or five years.

During the first few years after the plant was in operation it was customary to "sterilize" the sand beds every six months. This was done by placing about 200 pounds of soda-ash on the surface of the sand bed and then introducing live steam through the strainer system until the beds boiled for one hour. While this treatment cleaned the sand grains, it was found that it would be at least a week before the bacterial efficiency would be satisfactory, therefore the sterilization has not been used for the past fifteen years.

The strainers in the filters are known as "C-J", manufactured by the New York Continental Jewell Filtration Company. It has been found that it is necessary to repair some of the strainers about every seven years. This is done by removing the old rivets and gauze, and replacing the gauze and rivets, the men at the plant doing this work. There are 444 strainers in each filter, spaced on 6-inch centers. These strainers are screwed into lateral pipes, and the space is filled to the top of the strainers with concrete. Some of the lateral pipes are now being replaced after having been in continuous operation for over twenty years.

There are no automatic controllers on the effluent pipes from these filters. After washing the filters the effluent valve is partly opened and from time to time, as necessary, the operator opens the valve

until such time as the filters become clogged, when they are again washed.

The filter tanks, which are of 2½-inch cypress, show some decay in a few places and from time to time it has been necessary to replace some of the bands. The round bands seem to give better service than the flat bands.

Use is made of the water in the flume on its way to the first filtered water reservoir to operate a water wheel. This water wheel operates a pump which forces the filtered water to the laboratory and also operates the air pump which agitates the sulphate of alumina solution.

There are two filtered water reservoirs, both uncovered, and because of the constant motion of the water have given very little trouble from algae growths. The first reservoir has a capacity of about 3,500,000 gallons, and from it the water is pumped to a concrete reservoir of 5,000,000 gallons capacity. This concrete reservoir was installed in 1912. During the ensuing winters the ice pulled the concrete, in places, away from the reinforcing bars. In 1916 a cement gun was used to replace this concrete and since that time there has been no trouble due to the action of the ice.

In 1912, with a population of 38,000, the consumption was 6,275,000 gallons per day; during the year 1917, with a population of about 45,000, the consumption was 4,025,000 gallons per day. Since 1912 meters have been installed on nearly all services, which is the cause for the reduced consumption.

When this plant was first placed in operation bacterial examination of water was in its infancy. Previous to May, 1905, chemical and bacterial tests covering periods of two weeks were made four or five times each year. Since that time an extensive laboratory has been maintained and daily chemical and bacterial tests are made. Since these tests have been made it has been possible to keep the plant under control at all times and the results obtained show a better efficiency and more uniform results.

In determining the bacterial content of the water it has been found that gelatin media at 20°C. for forty-eight hours is most satisfactory. In determining the bacterial count all plates are made in duplicate and the average count reported. A large percentage of the filtered water plates are incubated for seventy-two hours and remain sterile at the end of this period. All sterile filtered water plates are recorded as containing 1 bacterium per cubic centimeter.

Table showing maximum, minimum and average bacteria per cubic centimeter (gelatin counts) unfiltered and filtered water supply of Elmira, New York

YEAR	UNFILTERED			FILTERED		
	Maximum	Minimum	Average	Maximum	Minimum	Average
1898	9,300	675	2,280	325	15	76
1899	26,300	524	6,019	860	6	121
1900	838	316	547	60	4	17
1901	2,690	796	1,394	35	7	17
1902	28,500	795	10,905	1,816	12	402
1903	29,000	300	7,646	2,000	20	230
1904	18,300	190	1,761	900	2	50
1905	45,200	520	7,256	530	6	70*
1906	45,600	450	7,433	420	4	43
1907	150,000	370	9,278	470	1	52
1908	83,400	208	9,375	870	3	61
1909	121,800	290	9,904	985	1	87†
1910	142,000	160	9,234	320	1	18
1911	112,000	120	9,516	120	1	7
1912	328,000	380	18,137	190	1	16
1913	120,000	340	7,127	92	1	9
1914	84,000	210	8,973	86	1	8
1915	155,000	380	8,910	98	1	6
1916	113,000	350	10,594	60	1	5
1917	89,700	200	6,872	70	1	6
Average.	85,231	379	7,660	515	4	65

* Daily.

† Hypochlorite first used.

During the past twenty years the average bacteria in the unfiltered water were 7660 per cubic centimeter while the filtered water contained 65 per cubic centimeter, a reduction of 99.15 per cent.

During the first twelve years when sulphate of alumina was used the average bacteria in the unfiltered water were 6153 per cubic centimeter and in the filtered water 102 per cubic centimeter, a reduction of 98.35 per cent.

During the six years when hypochlorite was used with the sulphate of alumina, the average bacteria in the unfiltered water were 10,313 per cubic centimeter, while the filtered water contained 11 per cubic centimeter, or a reduction of 99.90 per cent.

During the past two years when liquid chlorine was used with the sulphate of alumina, the average bacteria in the unfiltered water

were 8733 per cubic centimeter and in the filtered water 6 per cubic centimeter, a reduction of 99.93 per cent.

Since the plant was placed in operation 77.61 per cent of the 1 cubic centimeter samples of unfiltered water gave positive presumptive tests for B. coli communis; while 1.79 per cent of the samples of filtered water gave positive results, a reduction of 97.69 per cent.

Previous to the use of hypochlorite or liquid chlorine, 71.63 per cent of the unfiltered water samples and 9.87 per cent of the samples of filtered water contained B. coli communis, or a reduction of 86.22 per cent.

During the eight years since hypochlorite or liquid chlorine has been used, 82.91 per cent of the samples of unfiltered water and 0.53 per cent of the filtered water samples contained B. coli communis, or a reduction of 99.37 per cent. The use of calcium hypochlorite or liquid chlorine has increased the efficiency of this plant and reduced the cost of chemicals used in its operation.

In determining the turbidity, standards made from clay obtained from the watershed are used.

Table showing turbidity, in parts per million, of the unfiltered and filtered water supply of Elmira, New York

YEAR	UNFILTERED			FILTERED		
	Maximum	Minimum	Average	Maximum	Minimum	Average
1901	100	35	60.0	0.0	0.0	0.00
1902	110	35	67.0	0.0	0.0	0.00
1903	700	7	56.0	3.0	0.0	0.60
1904	500	20	62.0	0.0	0.0	0.00
1905	650	6	34.0	0.0	0.0	0.00
1906	1,900	6	72.0	0.0	0.0	0.00
1907	1,000	3	35.0	0.0	0.0	0.00
1908	800	2	35.1	0.0	0.0	0.00
1909	200	2	18.7	0.0	0.0	0.00
1910	700	2	23.6	0.0	0.0	0.00
1911	800	8	38.1	0.0	0.0	0.00
1912	2,500	8	58.5	15.0	0.0	0.09
1913	600	8	54.4	0.0	0.0	0.00
1914	500	5	40.9	0.0	0.0	0.00
1915	6,000	8	99.7	0.0	0.0	0.00
1916	3,500	3	74.9	0.0	0.0	0.00
1917	2,500	3	82.1	0.0	0.0	0.00
Average..	1,356	9	53.7	1.1	0.0	0.04

The average turbidity of the unfiltered water was 53.7 and the filtered water 0.04 part per million, a reduction of 99.93 per cent.

During the winter months great care has to be exercised. It is at this season that the filters are most likely to become air bound, and water containing some turbidity likely to pass the filters. Although the filters have no loss-of-head guages, the operator can tell when the beds contain air, and after a short wash the filters are again placed in operation. Wash water applied for one minute is usually sufficient to expel the retained air.

In determining the color, the platinum-cobalt method is used.

Table showing color, in parts per million, unfiltered and filtered water, Elmira, New York

YEAR	UNFILTERED			FILTERED		
	Maximum	Minimum	Average	Maximum	Minimum	Average
1901	40	20	28.1	0.0	0.0	0.00
1902	90	17	30.9	8.0	0.0	1.20
1903	45	11	23.0	5.0	0.0	0.60
1904	42	15	24.6	8.0	0.0	1.00
1905	40	10	18.5	0.0	0.0	0.00
1906	80	5	23.8	0.0	0.0	0.00
1907	50	0	18.4	0.0	0.0	0.00
1908	180	0	15.8	0.0	0.0	0.00
1909	45	2	12.1	0.0	0.0	0.00
1910	45	2	14.8	0.0	0.0	0.00
1911	50	6	19.2	0.0	0.0	0.00
1912	70	8	19.5	20.0	0.0	0.09
1913	45	8	16.6	0.0	0.0	0.00
1914	40	6	17.9	0.0	0.0	0.00
1915	60	3	16.9	0.0	0.0	0.00
1916	40	3	10.3	0.0	0.0	0.00
1917	60	6	17.9	0.0	0.0	0.00
Average..	60	7	19.3	2.4	0.0	0.17

During this time the average color of the unfiltered water was 19.3 and the filtered water 0.17 part per million, a reduction of 99.12 per cent. As previously stated, it is impossible to get a complete removal of the color when it is necessary to use lime or soda-ash.

Table showing alkalinity, in parts per million, unfiltered and filtered waters. Elmira, New York

YEAR	UNFILTERED			FILTERED		
	Maximum	Minimum	Average	Maximum	Minimum	Average
1900	100	88	94.4	95	70	83.8
1901	165	41	101.1	145	31	83.5
1902	68	33	53.4	53	12	36.2
1903	86	28	60.2	78	18	45.7
1904	73	15	42.5	62	0	31.5
1905	86	30	65.3	74	17	53.0
1906	107	15	55.1	92	7	43.4
1907	92	14	51.5	81	4	40.0
1908	103	15	62.6	112	7	57.3
1909	109	12	64.5	106	0	56.6
1910	106	13	67.0	106	6	63.4
1911	90	15	54.3	87	12	49.8
1912	103	11	58.6	98	4	51.9
1913	95	15	58.0	89	7	51.7
1914	100	11	62.0	97	7	57.5
1915	88	13	49.6	85	9	44.2
1916	103	12	57.0	96	6	50.8
1917	93	12	50.5	88	10	41.2
Average..	98	22	61.5	91	13	52.0

During this period 9.5 parts per million of alkalinity were used, while the average amount of sulphate of alumina used was 1.29 grains per gallon. On this basis, 1 grain of sulphate of alumina required 7.35 parts per million of alkalinity for decomposition.

In 1908 it is seen that the maximum alkalinity of the filtered water was higher than in the unfiltered; this was one of the times when it was necessary to use lime, because of an inactive alkalinity.

The amount of sulphate of alumina required to remove a given color or turbidity depends to a large extent upon the temperature of the water; the higher the temperature, the less coagulant is required.

The plant has been inspected and tested frequently by the State Board of Health.

Under the law, physicians are required to report cases of typhoid fever to the Health Officer; a violation of this law is punishable by a fine. When a case is reported an official from the Health Department visits the case, making a sanitary inspection of the premises, and also taking notes regarding the source of the water and milk supplies and other data.

Table showing average color and turbidity in parts per million, unfiltered water, and sulphate of alumina used in grains per gallon, Elmira, New York

YEAR	COLOR	TURBIDITY	ALUM
1898			0.50
1899			1.28
1900			1.03
1901	28.1	60.0	1.36
1902	30.9	67.0	2.18
1903	23.0	56.0	1.89
1904	24.6	62.0	1.68
1905	18.5	34.0	1.67
1906	23.8	72.0	1.57
1907	18.4	35.0	1.55
1908	15.8	35.1	1.52
1909	12.1	18.7	1.30
1910	14.8	23.6	0.98
1911	19.2	38.1	0.95
1912	19.5	58.5	1.11
1913	16.6	54.4	1.08
1914	17.9	40.9	0.78
1915	16.9	99.7	0.97
1916	10.3	74.9	1.11
1917	17.9	82.1	1.33
Average.....	19.3	53.7	1.29

During 1896, before the installation of the filter plant, Elmira was visited by a typhoid fever epidemic. During the period from January 3 to September 1, there were 370 cases of typhoid fever, with 36 deaths, a mortality rate of about 10 per cent.

During the three years 1895–1897 before the filter plant was in operation, there were 624 cases, with 73 deaths, of typhoid fever, the death rate being 78.8 per 100,000 population.

During the twenty years 1898–1917 that the filter plant has been in operation there have been 1507 cases, with 207 deaths, of typhoid fever, the average death rate being 29.3 per 100,000 population, making a reduction of 62.8 per cent in the death rate.

The average typhoid fever death rate during the 12 years that only sulphate of alumina was used was 39.9 per 100,000 population; compared with the rate before filtration this is a reduction of 49.4 per cent in the rate.

During the eight years in which the sterilizing solutions have been used with the sulphate of alumina, the typhoid fever death rate has

been 13.5 per 100,000 population. Compared with the rate when sulphate of alumina was used, this is a reduction of 66.2 per cent, and if compared with the rate before filtration was introduced the reduction would be 82.9 per cent in the typhoid fever death rate.

The entire improvement in the typhoid fever death rate is not due to the improvement in the public water supply. When the filtration plant was placed in operation there were over 1200 private wells in use. These wells were very shallow and examinations showed that at least 65 per cent of them contained B. coli communis. As the water was cool in summer time and "grandfather" dug the well and lived to a ripe old age, it has been a long and hard educational fight to prove that the use of water from some of these wells was dangerous. At the present time, when a case of typhoid fever is reported and the patient used well water, the Board of Health examines the water from the well and if it is found polluted the well is closed. This action upon the part of the Health Department has gone a long way toward reducing the typhoid fever death rate. The Board of Health also follows up the various milk supplies and there has been an improvement in the quality of the milk.

In the summer the Board of Health runs a publicity campaign, warning the people of the danger of swimming in the river.

During the past twenty years there were 1507 cases of typhoid fever, 604 or 40.1 per cent of which claimed to have used nothing but city water; 430 or 28.5 per cent claimed to have used well water exclusively; 247 or 16.4 per cent claimed to have used mixed well and city water, while 226 or 14.9 per cent of the cases were imported.

During the past twenty years there were 207 deaths from typhoid fever; 75 or 36.2 per cent were users of city water; 65 or 31.4 per cent used well water; 28 or 13.5 per cent used mixed water, while 39 or 18.8 per cent were imported.

The total mortality rate was 13.7 per cent; city water rate, 12.4 per cent; well water 15.1 per cent; mixed waters 11.3 per cent; imported 17.2 per cent. The imported mortality rate is the highest. This no doubt is due to the fact that the patients are not brought in to the hospitals until they are in a very serious condition.

In June and July, 1908, there were 40 cases of typhoid with 4 deaths; 31 of these cases were on one milk route, and upon investigation an unrecognized or concealed case of typhoid fever was found on the producing farm.

In October, 1912, there were six cases of typhoid fever on one milk route; investigations failed to reveal the cause.

Table showing average bacteria per cubic centimeter of filtered water, percentage of samples showing B. coli communis and total typhoid fever death rate per 100,000 population, Elmira, New York

YEAR	BACTERIA	B. COLI	TYPHOID RATE
		per cent	
1898	76		51.8
1899	121		35.6
1900	17		47.7
1901	17		28.0
1902	402		44.9
1903	230	20.00	64.5
1904	50	13.33	53.3
1905	70	1.37	25.2
1906	43	18.71	39.2
1907	51	4.17	25.2
1908	61	6.04	30.8
1909	88	5.47	33.6
1910	18	0.00	26.4
1911	7	0.00	13.2
1912	16	1.81	15.9
1913	9	0.46	10.6
1914	8	0.00	10.6
1915	6	0.17	9.6
1916	5	0.35	9.6
1917	6	1.43	11.9
Average.....	65	4.88	29.3

In February, 1913, there were eight cases on one milk route, one case of typhoid fever being found on the producing farm.

In 1914 there were six cases in one house; all used the same well water.

In 1915, out of 34 cases in October, November and December, 15 were on one milk route. It was reported that a typhoid carrier was found on the producing farm.

Time is certainly required to educate the public as to the value of a pure milk and water supply.

While the Elmira plant does not embrace all of the latest improvements in the art of water purification, there are few plants that are producing better results.

Mr. Hiram F. Jones has been superintendent and resident chemist and bacteriologist since 1905. The plant is now owned by the City of Elmira and is operated by the Elmira Water Board.

WATER SUPPLY SERVICE IN THE ARMY OF OCCUPATION IN GERMANY[1]

By Capt. Lucius A. Fritze

The water supply problem of the Army of Occupation was of a somewhat different character from that found in the First and Second Armies. The occupied area had not been the battle fields found in northern France, nor had the cities and civilian population felt the effects of the frightfulness of war. The cities were intact, clean and progressive; the homes were clean and well kept. Into such an area the victorious American army, men who had passed through a seemingly endless period of intense activity and nerve-breaking combat, entered. Hardships and strain were beginning to show their effect on the men. The individual resistance had been lowered and in many cases the physical condition was such that disease could easily make rapid inroads.

Under such conditions, the danger that existed in the use of grossly polluted water was apparent. In the majority of the cities and towns, ranging in population from a few hundred to 60,000, municipal water systems had been established, so the work devolved upon the army was not so much the construction of new water systems as the determination of the quality of the water and the installation of the equipment necessary for the sterilization of those supplies needing treatment. Before the organization of an army water supply service, divisional effort centered on this work proved, beyond a question of doubt, the necessity of establishing some means of sterilization. Within the division, each company had been supplied with a Lyster bag, a canvas water bag in which water is sterilized by means of chloride of lime. These water bags, as a rule, were stationed at the company kitchen with one man, usually, responsible for the care of the water. This means of water

[1] Presented at the Buffalo Convention, June 13, 1919. Publication authorized by the Board of Publications, Surgeon General's Office. The author was water supply officer of the Rainbow Division and of the U. S. Army of Occupation.

purification was very satisfactory under some conditions. However, in the area of the Army of Occupation such efforts were only producing false security. Billets for the men were scattered throughout the villages, sometimes at a considerable distance from the kitchen, and invariably raw water from taps or public fountains was used.

The high civilian typhoid rate found in the occupied area, a very apparent menace, and the fertilization of the soil with raw sewage as well as inadequate protection at the water sources, necessitated some effort along the line of water purification. Investigation showed the extent to which some cities permitted the water systems to decay. It was evident that throughout the entire war very little effort had been made to install new equipment, and in some instances necessary repairs had been neglected. The use of the residue from coal tar distillation for oil and grease showed its effect on the mechanical equipment.

In some of the cities having pumping equipment, water power was used. In others electricity and steam. Due to the shortage of copper, the electrically operated plants were seriously embarrassed. The shortage of rubber necessitated the use of various ingenious products.

In a large number of the smaller towns, hill-side springs were used, the water flowing to a reservoir and thence by gravity to the city. Wells located along a river, the water purified by infiltration through sand and gravel, were used. In others no effort had been been made to install a system, the water being supplied by shallow wells. A few of these cities showed potable water. In the valley of the Ahr River, the location of the famous Apollinaris mineral water, certain supplies were free from pollution. However, in the majority of cases throughout the occupied areas, conditions were such as to warrant the installation of apparatus for sterilization.

About the time concerted effort was made to improve the water supply conditions, the water supply engineers returned home and it became necessary to develop an organization for this work from the available organizations within the army. The area to be covered was large, divisions occupying from twenty to ninety cities each and corps and army troops occupying additional. Roughly, some eight hundred cities were in the occupied area, all of these, however, not being occupied by American troops. In order to cover this entire area and complete the necessary installa-

tions within a reasonable length of time, the following scheme was adopted.

1. To place the burden of responsibility for the survey work and the construction work on the division.

2. To maintain a minimum personnel at army headquarters and yet sufficient to maintain satisfactory liaison with the divisional personnel.

With this plan of organization it was possible to utilize the trained personnel within the division, thus avoiding a cumbersome organization at army headquarters and the inevitable delays usually encountered. Within the division, an officer (a chemist and bacteriologist or sanitary engineer) trained in water supply work, with a complete laboratory equipment, was on duty. He, with the laboratory personnel, would undertake the field survey work, gathering the necessary data as to the quantity and quality of the water, character of installations and necessary information for the installation of either liquid chlorine or chloride of lime equipment. The divisional engineers would supply the necessary personnel for the construction work. With additional assistance from army headquarters, both the laboratory and the engineers would be strengthened.

General orders previously issued definitely outlined the character of work to be undertaken by the engineering department and by the medical department. In the organization of this army water supply service, it was necessary to arrange the work so as to comply with these general orders. With this unavoidably complicated arrangement, definite plans were made. The necessary memoranda were issued covering the work to be expected from both departments.

In order to support this divisional personnel satisfactorily, the necessary engineer officers and non-commissioned officers were assigned to duty. Two officers were detailed as liaison officers, visiting the divisions and supervising in a general way the construction work. One non-commissioned officer familiar with water supply construction work was assigned to each division to take command of the construction detail. The divisional engineering detail, about ten men in each division, constituted the construction organization. The army non-commissioned officer assigned to duty trained the divisional personnel in the work involved and at the completion of an installation trained the necessary personnel, supplied by the organization occupying the town affected, to operate the equipment.

This plan of operating the various equipments required the services of two or three men on continuous duty. When the installation was completed, the responsibility for the care and treatment of the water fell to the medical officer of the town. The personnel operating this equipment, therefore, was responsible to the medical officer. The divisional water supply officer was used in the capacity of a consultant by these medical men and tested the water to determine the efficiency of the treatment.

A second personnel at army headquarters had been assigned to operate the central shop and to make the necessary installations in the area occupied by army and corps troops. In this shop all hypochlorite plants to be used in the divisional area were constructed and all liquid chlorine apparatus overhauled before delivery. One man from this personnel was assigned as repair man to be called upon to visit the divisions to repair liquid chlorine apparatus. The transportation necessary to carry out this work was available.

The supplies necessary to maintain the plants in operation were obtained by the engineers. The supply base for the army was established at Coblenz and the requirements within the division supplied from this point.

It was the policy of the army to have all equipment, as well as reports, records, etc., standardized. The necessary information regarding the character of a proposed installation was reported through the divisional water supply officer to the army water supply officer, who in turn forwarded recommendations to the engineers. If doubt existed as to the advisability of making a certain installation, the army water supply officer made a personal investigation. In recommending installations of equipment in the numerous towns showing polluted water, it was necessary to have knowledge regarding the length of time the places were to be occupied by American troops. It was certain that the army of occupation would be reduced in number and it was only a question of time before all the troops would be removed. With this object in view, plans adopted called for the initial work being completed in the larger centers first, especially along the Rhine Valley, the Moselle Valley and the Ahr Valley, and certain cities on the lines of communication. It was foreseen that in those towns occupied by a very small number of troops, it would be impractical to install expensive equipment. In such places it was necessary to compel all to use the water from the Lyster bag. In other towns where the general sanitary con-

ditions and the geographical location were such that the town would soon be evacuated, it was not the policy to undertake improvements.

In those cities having satisfactory pumping equipment it was recommended that liquid chlorine be used. In a few towns it was advisable to have automatic chloride of lime treatment. Some difficulty was encountered in those localities having hillside springs. However, with a reservoir available and a fairly uniform flow of water flowing into the reservoir it was possible to add the chloride of lime in a fairly uniform treatment. In those cities supplied by a series of springs, it was necessary to install several hypo plants.

Throughout the entire occupied area, it was observed that little effort had been made by the civilian population in the sterilization of the water supplies. Though the sanitary officers of the various "kreis" were familiar with the character of water supplied to the civilians in their respective districts, no effort on their part, apparently, had been made to improve conditions by sterilization. When approached regarding the work to be undertaken their attitude appeared to be that of doubt. Both typhoid and paratyphoid fever were prevalent, though not in epidemic form. In such cities as Coblenz and other large Rhineland towns, the water supply, after a considerable number of examinations, proved to be potable. The water for Coblenz is obtained from a series of wells along the Rhine River with infiltration through sand and gravel as the means of purification. The water is pumped to elevated tanks and the city is supplied both by gravity flow and direct pressure. However, as a matter of precaution, the entire water supply was treated with liquid chlorine.

It will be observed that the entire work of the army water supply service centered on the sterilization of the established municipal supplies, using both liquid chlorine and chloride of lime for treatment. Extensive construction work involving the erection of elevated tanks, concrete reservoirs and the laying of pipe lines, was unnecessary. Upon the completion of the water supply organization for the survey and installation work, the principal difficulties encountered were training personnel to operate the various installations, caring for repairs and maintaining satisfactory control to insure sufficient treatment. However, these difficulties were not so serious as to interfere with the program mapped out for the water supply service, nor did they dampen the ambition of those in charge to supply the army in Germany with pure drinking water.

THE WATER SUPPLY OF THE OLD HICKORY WORKS[1]

By Oscar E. Bulkeley

In the latter part of 1917, the War Department began to realize the need of greater capacity for the production of smokeless powder. Up to that time, the E. I. Du Pont de Nemours Company of Wilmington, Del., had played a most vital part in building plants and furnishing powder to the Allies. Its long years of experience in all kinds of powder manufacture, as well as wide knowledge gained in building and operating plants to supply the Allies, made this company peculiarly qualified to aid the War Department when the need was finally appreciated by that Department. The company drew up plans for a government plant, giving the government all the benefit of its organization and highly specialized knowledge of powder manufacture. The Du Pont Engineering Company, organized within the parent company for handling this large Government work, was given the contract on January 29, 1918. By this agreement, the Du Pont Engineering Company was made the agent of the Government to construct the plant under the supervision of the Government. This contract was superseded on March 23 by another which gave the company greater freedom of action. Under the terms of the latter contract, the company guaranteed completion of the first unit at an earlier date, with consequent earlier production of powder. At the same time the plans were revised to give a daily capacity of 900,000 pounds of powder, an increase of 80 per cent over that contemplated in the first contract.

Old Hickory Works, as the plant was christened, is located at a bend in the Cumberland River about 15 miles east of Nashville, Tenn. It was built for the Government at cost plus the contractor's profit of One Dollar. It is the largest smokeless powder plant in the world, seventy times the size of the largest plant of its kind in existence prior to 1914. Surveys were begun February 6, 1918. Ground was broken March 8. Powder was being produced July 1,

[1] Read before the Illinois Section at Urbana on March 26, 1919. Government permission for publication in the Journal only has been granted.

two months ahead of contract agreement. As a tribute to this company's organization and ability, let it be said that building of this mammoth plant and placing it in successful operation in so short a time is one of the most marvelous achievements of the war. The entire plant, with the exception of certain special features, was designed by the engineering department of the E. I. Du Pont de Nemours Company.

The manufacture of smokeless powder requires large quantities of water. When the Old Hickory Works was planned, it was therefore necessary to consider its water supply very carefully, for it must be entirely adequate and reliable. Approximately 100,000,000 gallons of raw water daily would be required, of which 65,000,000 gallons would have to be filtered. The source of water supply, of course, was immediately determined by the location of the industry on the banks of the Cumberland River, or perhaps it would be better to put it the other way and say that accessibility to the Cumberland River, with its abundant water, determined the location of the industry.

The Old Hickory Works water system consists briefly of the following:

1. Two intake pumping stations.
2. Three large parallel wood stave pipe lines about 1½ miles long connecting the intake with the filtration plant.
3. A booster pump house midway between the intake and the filtration plant for furnishing raw water under pressure for cooling purposes.
4. The filtration plant, consisting of alum house, laboratory, five coagulant basins, 96 filter tanks and two reservoirs.
5. Power house flume and 12 service pumps.
6. Distribution systems, which also include the village water works.

The first four items only will be discussed.

Intake pumping stations. In the development of the water supply, there was one condition to be met which was the controlling feature in the design of intake and pumping stations. This was the wide variation in level of the river from the low-water to the high-water stages. Low-water elevation is 401.6, Government datum, while the maximum recorded stage is 456.0, making a total variation of about 54 feet. The pumping station must be waterproof and, to be substantial, must be constructed of massive concrete situated on bed rock, for the water pressure to be resisted would be very heavy.

Furthermore, there must be sufficient weight to prevent floating during maximum flood conditions. To give an added factor of safety, the pumping resources were divided, two stations being built 200 feet apart on centers, the downstream or No. 2 station 600 feet south of Government lock No. 3. At this point the Cumberland River flows due north. The Foundation Company designed the concrete details and also furnished a foreman to supervise the construction work.

Within a cofferdam built of lock steel piling, excavation was carried to bed rock at elevation 383. The foundation consisted of concrete 5 feet in depth, properly keyed into the rock. This brought the floor of the intake chambers to elevation 388, which is the bed of the river. The top of the concrete walls is at elevation 458, or 2 feet above the maximum recorded flood stage and 75 feet above the rock foundation. Above the top of these concrete walls is built a metal-covered frame super-structure. The stations in plan are 69 by 28 feet outside dimension at base, exclusive of the screen chambers.

The walls are reinforced, starting with a thickness at the base of 5 feet and decreasing to 2 feet at the top. The side walls are tied together with reinforced concrete beams in five sets vertically and three in each set horizontally, a total of fifteen beams. Concrete was mixed in the proportions of 1: 2: 4 in the beams and floors and 1: 2½: 5 in the walls. Truscon waterproofing paste was used in the proportion of 5 pounds per cubic yard of concrete. Construction joints were made by an insert 12 inches deep, one-third of the width of wall. On January 8, 1919, when the water stood 40 feet above the pump level, only slight leakage occurred. The screen chamber is divided into halves, so that one-half of the station can be shut down at a time, and is provided with trash rack, stop logs and double sets of screens.

Each station is equipped with five split-suction volute pumps driven by 300 horse power electric motors and designed for a maximum head of 152 feet. The characteristic curve of the pumps is quite flat, so that the capacity ranges from 8500 gallons per minute at 112 feet head to 0 at 160 feet head. The difference in elevation between the pumps and filtration plant gives a static head at the center of the pump shaft of 84 feet. The rated capacity of each station is, therefore, 42,500 gallons per minute or 60,000,000 gallons daily, with space provided and suction pipe installed for two additional pumps.

Each station is equipped with fan and ventilating ducts for supplying fresh air to the pump level, also a sump pump of 400 gallons per minute capacity driven through a vertical shaft by an electric motor located on the main floor above the flood stage. The switchboard is located on a landing two flights of stairs above the pump level. Three 600 kilowatt transformers are supported on the main floor at the top of the concrete walls.

In spite of delay caused by high water flooding over the cofferdam once or twice during construction, a very good record was made. Ground was broken for the first station on April 18, and the first pump was placed in service on June 20, sixty-three days later.

One of the most interesting things in connection with construction and operation of this intake was the condition under which operation was first undertaken. The walls of the pit were approximately a third the way up, at elevation 419. Data from past records showed that this was safe for that season of the year. Means of access to the pump level was by climbing down the form bracing. There was no cover except tar paper protection about 6 feet square over the motors. The switchboard was a temporary one set up a hundred feet outside the station and 2300 volt current was supplied direct from the power house, whereas the permanent installation called for 2300–6600-volt step-up transformers at the power house and a corresponding step down at the intake. By the time the transformers arrived, the line loss had become as high as 20 per cent.

Pipe lines and booster pump house. All the water delivered by these stations was to be conveyed through three 42-inch wood stave pipe lines as far as the booster pump house, a distance of about 3800 feet and from this point on to the filtration plant, a distance of 4000 feet, through three 36 inch wood stave pipe lines. At the so-called booster pump house about one-third of the raw water is diverted and delivered through a separate raw water distribution system to the sulphuric and nitric acid plants, to be used for cooling water.

This booster pump house is equipped with motor-driven, horizontal, centrifugal pumps of the double-suction, horizontally split case type. Two pumps have a capacity of 3750 gallons per minute and four pumps have capacity of 7500 gallons per minute against a head of 120 feet, making a total rated capacity of 37,500 gallons per minute or 54,000,000 gallons daily.

All the wood stave pipe used at the plant is machine-bound and made up in the factory in random lengths. The greater part of it, at

least, is manufactured from best white pine. Some troubles were experienced in the operation of these wood stave pipe lines, mostly during the first few weeks of service. Occasional failures developed, some due to defective bands or resulting from injured bands. Warping of the staves and shrinkage caused by exposure to the weather were quite serious in certain cases.

Of course, it is well to bear in mind that this pipe was subjected to an unusually severe test on account of the very magnitude of the work undertaken at Old Hickory. There was the constant stimulus to turn out powder in ever increasing quantities for the support of the American forces. In the eagerness to complete any part of the work when production definitely awaited its completion, the work was literally driven to the limit. Labor was inefficient and railroad deliveries were such that materials must be taken when they could be obtained. Undoubtedly, the wood stave pipe installed in the plant received rough handling and most of it withstood the weather for several months prior to installation. However, there is no question of the appropriateness of its use. The cost was probably one-third of what cast iron or steel would have cost and either of the latter, if obtainable at all in such quantities, would have been so delayed in manufacture that powder production could never have been realized as early as it was. Experience with wood stave pipe proves that it is highly desirable when placing new pipe in service to allow several days for the wood to soak and swell, during which time the pressure should be very gradually increased up to the specified working pressure.

Each one of these pipe lines is provided with air release valves at high points and one 12-inch air vent open to the atmosphere at the booster pump station. There are 24-inch risers from the wood stave pipes extending up to tees, the branch openings of which provide connection to the suction header of pumps. The 12-inch vent pipe is attached to the vertical leg of this 24-inch tee.

These air vent pipes were the means of one peculiar phenomenon which proved very troublesome in operation. The elevation of the booster pump house floor and of the surface of the water in the subsidence basins at the outlet end of the main pipe lines is practically the same, so that the only head on the suction side of the pump at the booster pump house is the friction head existing between there and the subsidence basins. Any sudden variation in the discharge of water at the intake, caused by the interruption of electric current

or the starting or stopping of pumps there, produces sufficient surge in the pipe lines to cause an inrush of air at the air vents, uncovering the suction of the pumps at the booster pump house. It is therefore necessary always to be careful in starting or stopping pumps at the intake to avoid interrupting service at the booster pump house.

Alum house. At a distance of about 300 feet before reaching the subsidence basins, water destined for the filtration plant is treated with sulphate of alumina. This is accomplished in the alum house containing the coagulant feeding apparatus. Storage for 700,000 pounds of alum is also provided next to a railroad siding.

The feeding apparatus is arranged in two units of three solution tanks each. These tanks are 10 feet in diameter, constructed of cypress staves 10 feet long and 2 inches thick. Each tank has a dissolving tray, float indicator and graduated scale board for indicating the height of solution, and is also provided with agitators for agitating and maintaining a uniform density of solution. These agitators are driven by a bevel gear and pinion actuated by a friction clutch on each agitator, so that any agitator or any individual tank may be thrown out of use. The main shaft over the tanks is driven by belt from an overhead line shaft.

From the tanks the solution flows into orifice feed boxes about 18 by 24 inches and 18 inches deep, of cast iron, lead-lined, having a float-valve inlet control. The outlet is provided with an acid bronze calibrated orifice feed valve for measuring the flow into another feed box, called the constant-head feed box. This is also cast iron, lead lined, and has a fresh water connection controlled by a ball and float for admitting sufficient fresh water in addition to the solution to maintain a constant head on the pump suction. There is a motor-driven centrifugal pump for each tank, with a capacity of 15 gallons per minute, which pumps the solution into any one of the 36-inch raw water lines as desired.

The principal feature of the feeding apparatus is its exceeding flexibility. A $1\frac{1}{2}$ inch lead feed pipe runs from each unit to each one of the 36-inch raw water lines, thus making two feed pipes supplying each raw water line. Coupled with this duplication, any set of feed boxes and pump may take the solution from any tank in the unit and deliver it into any one of the three pipes.

Subsidence basins. Strangely enough, data on Cumberland river water were not available from which to determine the proper treatment for filtration. However, high turbidities were to be expected,

as was later found true in the actual operation of the plant. For the sake of low first cost, a period of only one and one-half hours coagulation was provided. There are five reinforced concrete subsidence basins, 150 by 59 by 13 feet deep, with a capacity of 800,000 gallons each. The three 36-inch wood stave lines discharge into a common cast iron header, which in turn delivers into each basin through a 36-inch pipe controlled by a sluice gate at the basin. The outlet from the basins to distributing or coagulated water flume may be controlled by three 20 by 20-inch sluice gates. Each basin has an overflow and three 12-inch drain valves along the center axis.

Filter plant. The filter plant consists of eight units of twelve filters each, making a total of 96 filters. They are of the gravity, rapid sand type. While reinforced concrete units could have been built for the same cost, wood tanks were favored because they could be erected in less time and would have a much higher salvage value if it were ever desired to move the plant at some future time. The total filter capacity is 65,000,000 gallons daily, exclusive of wash water, which is based upon the customary practice of 2 gallons per square foot of area per minute. The plant is very substantially built but with none of the artistic valve stands, loss of head controllers and other appurtenances found in most municipal plants. It was built to deliver clean, pure water, free from turbidity and harmful bacteria, and it is entirely successful. Six filters in each unit are placed in a row on both sides of a pipe gallery where there is an influent pipe and wash-water pipe line common to the twelve filters. This pipe gallery is immediately under the operating floor and in turn the filtered water gallery is directly under the pipe gallery, the floor of the latter being properly protected to prevent any water which might be discharged upon it from passing through the floor and into the filtered water. The filters themselves are over a wide concrete drain which carries all waste water from washings into the plant drainage system.

The filter tanks are 17 feet in diameter, having staves 7 feet 6 inches long, built of first quality well seasoned redwood lumber, $2\frac{3}{4}$ inches thick. Each tank is bound with seven $\frac{3}{4}$-inch round steel hoops, each hoop having three substantial draw lugs. Each tank has a 3 by 6-inch segmental shelf around the inside, supporting an 18 by $\frac{3}{16}$ inch sheet steel plate and a semi-circular steel trough across the center of the filter, communicating with the trough formed by this segmental shelf and the 18 by $\frac{3}{4}$-inch sheet steel plate, all forming

the wash water and distributing trough. The collection system consists of a semi-circular cast iron manifold which rests on the bottom of the filter tank. On each side of this manifold are attached $1\frac{1}{2}$ inch galvanized wrought iron strainer pipes placed on 6-inch centers. The strainer pipes have two rows of orifices approximately $\frac{3}{16}$ inch in diameter spaced 6 inches apart in rows at an angle of 45 degrees off the vertical axis, with the orifices on the lower side of the pipe nearest the filter floor and arranged on 3-inch centers, staggered. The strainer pipes are capped on the outer ends. The connection to the effluent and wash water piping system is made through the bottom of the tank and into the center of the manifold.

Gravel was placed in five layers. The size and depth of each layer are as follows:

LAYER NUMBER	PASSING SCREEN WITH OPENINGS AS BELOW	RETAINED ON SCREEN WITH OPENINGS AS BELOW	DEPTH
	inches	*inches*	*inches*
1	$2\frac{1}{2}$	1	9
2	1	$\frac{5}{8}$	4
3	$\frac{5}{8}$	$\frac{3}{8}$	2
4	$\frac{3}{8}$	$\frac{3}{16}$	2
5	$\frac{3}{16}$	10 meshes per inch No. 20 wire	1

The gravel was graded and placed very carefully. The sand is a selected grade of hard silicate material, free from loam, clay, vegetable matter, etc., having an effective size of not less than 0.35 mm. nor more than 0.55 mm. and a uniformity coefficient of not less than 1.6 nor more than 1.8. The sand is about 30 inches deep, the top of it coming practically even with the bottom of the wash water troughs mentioned above. Both the sand and gravel came from a bank near Montgomery, Ala.

Washing the filter bed is accomplished in the usual manner by a reversal of flow, using filtered water. The specifications called for a minimum wash rate of 15 gallons per square foot of filter area per minute. Since the rate of filtration is 2 gallons per square foot per minute and equivalent to a velocity or drop of $3\frac{1}{4}$ inches per minute on top of the filter bed, the wash rate recommended is $7\frac{1}{2}$ times the rate of filtration and equivalent to a rise of 24 inches per minute. Practice showed that with this rate the fine sand particles

were being lost. A rise of 18 inches per minute is the maximum safe wash rate. The washing process requires five or six minutes for each filter, and under normal conditions of water, washing once every twelve hours has proved satisfactory, although six-hour periods have been necessary at times. The amount of wash water averages about 4 per cent; 2500 gallons per minute are required for washing one filter.

As no loss-of-head controllers were provided, it is necessary to rate each filter from time to time. This is done every hour by closing the influent valve and by means of a hook gauge observing the number of seconds for the water to drop $3\frac{1}{4}$ inches. From a specially prepared table the daily rate of filtration corresponding to the time may be read. The time at full rated capacity is sixty seconds. The sum of the ratings on all the filters gives the rate of filtration of the entire plant.

According to specifications, the filters were to be operated under a head not to exceed 12 feet. As a matter of fact, it would be impossible to exceed this, as there is only 12 feet difference in level between the water on the filters and that in the filtered water gallery.

A filtered water flume extending along the entire side of the filter house receives water from the filtered water gallery of each unit, delivering it over 12-foot wide weirs into either clear water reservoir as desired.

Reservoirs. The two reservoirs are adjacent to the filter house, the outer wall of the filtered water flume serving as one wall of the reservoirs. They are 200 feet square in plan, $9\frac{1}{2}$ feet deep, built of reinforced concrete, provided with cover, and a central baffle wall insures good circulation. Their total capacity is 5,000,000 gallons or two hours storage.

The floors are 6 inches thick, reinforced with $\frac{1}{2}$-inch square rods placed 2 feet on centers both ways. The walls, 18 inches thick at the bottom and 12 inches at the top, rest upon reinforced footings 18 inches deep, which act as a cantilever beam 2 feet long on the exterior and 4 feet long on the interior.

Water discharges from each reservoir through two 42 by 42-inch sluice gates into a valve chamber, thence by gravity through four 36-inch wood stave pipe lines to the power house flume, where it is taken by the service pumps and delivered throughout the entire works and the village.

Filtered water is sterilized as it enters the reservoirs, four chlorine

machines being provided for this purpose in the chlorine house built directly above the weirs. They are of the solution-feed manual-control type. These machines take chlorine gas from steel cylinders, measure it in an indicating float meter and mix it with the proper amount of water, then feed it to a chlorine grid placed on the face of the weir, which gives a thorough distribution of the chlorine solution. A drop of 12 inches from the filtered water flume to the reservoir aids in diffusing the chlorine. The usual treatment is from 2 to 3 pounds of chlorine per million gallons of water filtered.

Ground was broken for the filter plant on March 30. The first unit was placed in service on June 20, eighty-two days later. Construction work was stopped seven months after breaking ground, at which time the entire installation was practically completed.

Probably the most striking feature in the construction of the filtration plant is the method employed for placing concrete. The filter house only is 130 by 402 feet. Together with the reservoirs and subsidence basins the ground covered is approximately 480 by 402 feet, over 4 acres. Pouring the entire quantity of concrete was accomplished in two set-ups of a steel tower. The high-line method of suspension was employed, using steel chutes for conveying the concrete to the desired location. Concrete was mixed with a one-yard batch mixer. The tower stood 180 feet high and distributed concrete through a radius of 300 feet. The maximum pour was 316 cubic yards in twelve hours. A similar tower was used at the intake. Here the concrete was more massive and a better record was made, 396 cubic yards being placed in ten hours.

Laboratory. In one wing of the alum house is a laboratory equipped with apparatus and a complete supply of chemicals for making all the required determinations of the quality of the water. Alkalinity of raw, settled, and filtered water is determined twice daily. Turbidity of raw, settled and filtered water is determined every three hours. Bacterial counts of raw water and of filtered water taken at various points throughout the plant, particularly the village, are made daily. Fermentation tubes are also sown daily and gas formers are followed up with exhaustive tests for determination of the presence or absence of B. coli. Color and residual chlorine are also determined from time to time.

Features of operation. The month of November, 1918, was the month of largest consumption. The average turbidity of raw, settled and filtered water was 677, 120 and 1.41 parts per million respec-

tively. The average alum treatment was 1.5 grains per gallon. The average alkalinity of the raw water was 70 parts per million. Bacteria per cubic centimeter standard agar at 37½°C. of the raw water averaged 864, of the treated water 6. In December the turbidity of raw, settled and filtered water averaged 314, 96 and 0.25 respectively. The alum used was 1.36 grains per gallon. The alkalinity of raw, settled and filtered water averaged 63.5, 57, and 55 respectively. The bacteria per cubic centimeter of raw water averaged 921, of treated water 3.1. B. coli are found present in practically every raw water sample. Even though water for the village must travel 1½ miles, there to be stored in a reservoir and repumped into the village distribution system, analyses of samples taken daily at widely scattered locations in the village show a uniformly high quality, low bacterial count and no indication of B. coli.

The only difficulty experienced in delivering an entirely satisfactory effluent occurred during unusually high water. The Cumberland River reached a maximum stage on January 8, 1919, approximately 32 feet higher than the low-water stage. On January 2 and 3 extremely high turbidities prevailed, 4800 parts per million. On December 31, there was a noticeable drop in the alkalinity of the raw water, which continued to decrease until a minimum of 25 parts per million was reached on January 8. While the filtered water tested all right bacterially, turbidities ranging from 1 to 15 parts per million became common. The alkalinity was not high enough to neutralize sufficient aluminum sulphate to cope with such excessively high turbidities. The result was that too much work devolved upon the filters. A stock of soda ash is now kept on hand which may be used to increase the alkalinity artificially. It is confidently expected that with the aid of this soda ash, any like emergency in the future can be met with satisfactory results.

At full capacity the plant would remove 131 tons of suspended matter daily, on an average. With a turbidity of 4800 parts per million, such as prevailed early in January, the removal would be 1280 tons in one day. The cleaning of the coagulation basins is done as needed, usually about once in thirty days, and is accomplished by opening the center drain valves and washing out the sediment with fire hose. The deposit is very easily washed down into the drainage system in this manner.

The first unit put into operation presented at least a novel appearance. One would doubt that a plant could be operated under such

conditions unless one had witnessed it. None of the fittings or pipe for the header in front of the coagulation basins had arrived. One 36-inch wood stave pipe had been completed but it was raised up so that it discharged over the top of the basin. This of course did not aid the process of coagulation. The opening in the concrete for the sluice gate was bulkheaded. The coagulated water flume and filtered water flume were bulkheaded off from the units under construction. A small temporary wash water line only was available. Temporary galvanized iron alum feed lines only had to be relied upon. Neither reservoir was completed, the only storage being that of the power house flume and this could only be filled two-thirds full. There was no roof over the filter house and the filter valves had to be operated without valve stands, and there was no laboratory equipment whatever Conditions gradually improved, but for over two months the plant was operated with a maximum of only six minutes storage capacity, but these will be remembered as days when the saving of time meant the saving of lives. Any practicable means or makeshifts which would make possible earlier production or definitely increased production of powder were highly justified.

SOME WATER SUPPLY PROBLEMS IN PALESTINE[1]

By Capt. H. Y. Carson

Following the reclamation of the Holy Land by the British troops under the able guidance of General Allenby, one of the first duties of the American Red Cross Engineering and Medical Units sent in February, 1918, from America to Palestine by way of South Africa and India was that of surmounting the troubles occasioned by improper housing and lack of sanitation. The great difficulty of obtaining ample supplies of pure water was perhaps the primary cause for the greatest share of the troubles.

On account of the presence of submarines in the Mediterranean Sea, the American unit, consisting originally of 57 persons under Dr. E. St. John Ward, skilled surgeons, engineers, social workers, nurses and business experts, reached lower Palestine after ninety days of water and land travel around South Africa, India and through Egypt. The ship on which the unit sailed was loaded in New York with 1150 tons of specially selected engineering and medical equipment, which was trans-shipped at two places before reaching Jerusalem; once at Colombo, Ceylon, and again at Port Said, Egypt. The journey from Egypt to Jerusalem was made over the newly constructed military railway which Allenby's able engineers flung across the desert with the fighting army at the rate of $1\frac{1}{2}$ to 2 miles per day. This railway crosses the Suez Canal at Kantara and traverses the desert which lies south of Palestine.

The first city of importance in Palestine reached by this railway is Gaza, where Allenby fought his hardest battle against the unspeakable Turk and Hun. The line then proceeds northward to the equally ancient city of Ludd and turns eastward through the steep hills with an ever-bending course to the old city of Jerusalem.

Before Allenby undertook to cross the sun-scorched desert into Palestine, he conceived the idea of pumping water from the "Sweet Water Canal" whose source is the Nile, and delivering an adequate

[1]Read before the Buffalo Convention, June 13, 1919.

supply for the five complete army divisions which made up his attacking force. This project called for an immense amount of material and labor in the setting up of complete pumping and filter plants having a capacity variously estimated at 5,000,000 to 10,000,000 gallons daily. The 12-inch force main which crosses the Suez (likewise near Kantara) parallels for the greater part of its course the military railway mentioned above. The pumping plant at Kantara delivered the water into a 12-inch force main which terminated about 50 miles beyond the desert in a reservoir. There the water was pumped through a 10-inch main about 40 miles, and was then

THE WELL OF ABRAHAM AT BEERSHEBA

This deep well, like many others in Palestine, yields water of excellent quality, in spite of the great age of the well.

pumped a third time through an 8-inch main 50 miles long, to Gaza. These pipes had been intended for oil transit lines, but were never used for that purpose. They were laid on the surface of the ground and then covered with about 1½ feet of sand or soil to protect them from the direct rays of the sun.

In spite of the fact that the water was forced through the many miles of pipe at a rate sufficient to give every man in the army an allotment of 3 to 4 gallons per day, and animals from 5 to 10 gallons per day, the problems of conveying the water on the backs of pack animals or by "lorry", often under shell fire, to the ever advancing

front line proved extremely difficult at times. During several hard days of fighting near Gaza the British soldiers in many instances succeeded in maintaining their life on an allotment of 1½ pints per capita per day. Of course, this water was used for making tea.

These waters of the Nile served only the lower portion of Palestine. The supplies for such cities as Jerusalem, Gaza, Beersheba,

THE DOME OF THE ROCK MOSQUE

Here, in the heart of Old Jerusalem, Solomon built the Temple, and water from the Living Springs 16 miles distant emerged from fountains.

Hebron, Eskalon, Jaffa, Jericho, Nazareth, etc., are obtained from local sources, springs, wells, etc., some of which yield an abundance of pure water, others a scanty supply. Under the surface can be located plenty of water in all the regions of the territory which lie within the ancient boundaries of Palestine, that is from Beersheba to Dan, and from the Mediterranean Sea to the Jordan River.

The climate of Palestine is subtropical, being somewhat similar to some of our own semi-arid states in the Southwest. It seldom rains during seven out of twelve months of the year, and although the rainfall at Jerusalem is said to equal about 30 inches per annum, the geological structure of the country accounts for the fact that very little water is retained on the surface of the ground. The surfaces are stony

WATER PEDDLER CARRYING WATER IN A LEATHER BAG THROUGH A STREET IN JERUSALEM

and consist for the most part of porous limestone which permits the water to disappear quickly. However, the water-table is fairly close to the surface, as evidenced by the excellent shallow wells and springs that are found in the dried up "wadys" amongst the barren hills.

Notwithstanding the fact that Palestine is hardly larger than one of our smallest states, New Hampshire, its climate is quite variable.

On the western slope near the sea the Plains of Sharon are quite suited for the production of semi-tropical fruit trees, such as oranges, dates, etc., while at Jerusalem, which is about 2400 feet above the sea level, the climate changes quite perceptibly. To the east of Mount Moriah and the Mount of Olives lies the great Jordan River valley, in reality a huge geological "fault" with the Dead Sea lying 1300 feet below sea level. Viewed from the Mount of Olives on a clear day the Jordan River stretches out before an observer's eyes like a large mirrored ribbon coming down from the snow peaks of Mount Hermon to the north, and joining the placid Dead Sea glistening in the resplendent sun that pours over the blue hills of Moab lying on the east side of the river.

The springs 16 miles south of Jerusalem, which are probably the same ones given by Caleb[2] to his daughter, are used as the best modern source of water supply for Jerusalem. The British engineers installed a 300,000-gallon per day pump operated by two 66 h. p. Hornby gasoline engines at the springs and laid a 6-inch force main to the city in about 70 working days. At Jerusalem the water is distributed from a reservoir on top of a hill.

The pools of Solomon located about 3 or 4 miles closer to Jerusalem are large impounding reservoirs capable of holding 80,000,000 gallons. Other springs surrounding Jerusalem can, without serious difficulty, be developed to supply by modern methods quite an abundant and wholesome supply of water in a quantity undreamed of by the ancients.

Each house in Jerusalem has a cistern, which was formerly used for storing rain water. The British sanitary department compelled the householders to clean them thoroughly, and they were then filled with wholesome water by means of temporary pipes. The vendor of water from a skin bag slung over his shoulder and the water fantanzies on donkeys and camels must give way to the less picturesque but more practical and sanitary methods of distribution.

To the engineer who has been privileged to work with the valiant British in the reclamation of the Holy Land, there comes with emphatic force the thought that America, with its abundance of resources and the capacity of its manhood to develop those abundant resources, is truly blessed among the modern nations of the earth.

[2] Joshua, 15:19.

INDEX NUMBERS AND SCORING OF WATER SUPPLIES

By Abel Wolman

At the 1918 annual convention of the American Water Works Association there was presented a paper[1] by Mr. Robert B. Morse and the author on "The Practicability of Adopting Standards of Quality for Water Supplies." In that discussion an attempt was made to indicate the practical difficulties in the way of formulating a standard for water supply quality. As a member of the 1918 Committee on Standards for Water Supplies, the author has placed before himself the further task of discussing the principles of standardization or of its analogue, the scoring of water supplies. For even after the practical difficulties of bacteriological technique, of interpretation, and sanitary survey have been solved, the method and the logic of scoring still remain to be analyzed. In order to examine the principles of scoring, it has been necessary to formulate them with some exactness. In the search for such principles in other sciences, it was soon apparent that the choice and construction of index numbers in the field of economic statistics afford a problem so closely analogous to that of the standardization of the quality of water supplies that it was thought desirable to make use of some of the concepts already so carefully developed in the former field.

This paper has for its object, therefore, the presentation of the principles of water supply scoring, a comparison of these methods with similar ones in index number making, the discussion of their points of analogy and difference, and the development of certain data as guides in the more simple problems of water supply standardization. The first part of the paper will deal with the general aspects outlined above, while the second part will present the more specific material suggested in the above program.

[1] See Journal, September, 1918, p. 198.

SCORES AND INDEX NUMBERS

The quality of a water supply is a complex function of a series of attributes of varying importance. The measure of the potability of a supply, in the broad sense, is simply a weighted average, while the scoring of a water supply becomes, in like manner, a process of developing a weighted average, a single expression disclosing all the significant characteristics of the complex data which go to make up the concept of "potability." When we speak of the quality of water we mentally focus our judgment upon the various factors of bacterial and chemical analyses, of control of purification systems, and of sanitary surveys. By comparisons of different waters an unconscious weighting of attributes results. This necessity of weighting suggests the further search for quantitative, concentrated or summarizing expressions. The development of such expressions in the field of water supply quality has issued in the form of a standard or score. When this conception of the measure or standard of quality as a weighted average is extended to include comparisons of waters at different places and at different times, we approach the concept of the index number developed in statistical method. This analogy between the score and the index number is important, since the study of the latter points out the possible advantage in or the barriers to the use of the former.

Secrist states[2] that

> The purpose of an index number is to reduce to a common denominator the qualities of different factors or phenomena so as to allow comparison. . . . . It is to translate absolute into relative qualities in order that comparisons may be made. Moreover, index numbers are summaries direct or indirect of things having a common quality. . . . . They represent this quality as an aggregate or average at different times for purpose of comparison.

He explains further that such index numbers represent divergent things, responding differently to conditions and occupying different positions in the economy of business.

In a similar manner the problem with which the sanitarian is usually concerned is the comparison of different qualities of the same or different supplies, at the same or different times. He is

[2] Secrist, Horace, An Introduction to Statistical Methods, p. 297, Macmillan.

confronted, therefore, with difficulties similar to those of the economist who attempts to study the general drift of prices, of wages, or of rents. In each case a "direct or indirect summary of things" having a common, but not necessarily the same, significance is essential. The economist, through a number of years of study, has found the solution to his problem, and a survey of his method of developing the index number and its principles will point the way for the student of water supply scoring. It remains to be seen, however, whether the same principles may be adopted in both fields.

The operations involved in making a price index number, for instance, are similar to those followed, to a greater or less extent, by the various investigators of water supply scores. These operations, adapted to our problem of water supply scoring, are briefly summarized[3] as follows:

(a) Defining the purpose for which the final results are to be used.

(b) Deciding the numbers and kinds of conditions or concepts to be included.

(c) Determining whether these characteristics shall all be treated alike or whether they shall be weighted according to their relative importance.

(d) Collecting the actual figures for the characteristics chosen and, in case a weighted series is to be made, collecting also data regarding their relative importance.

(e) Deciding whether to measure the average variations of characteristics or the variations of a sum of actual characteristics.

(f) In case average variations are to be measured, choosing the base upon which relative qualities shall be computed.

(g) Settling upon the form of average to be struck.

A study of the above series of processes discloses the close analogy between the ideas underlying the development of an index number and those leading to the formation of a standard of quality. The factors outlined in (a), (b), and partially in (d) have been recognized generally in earlier attempts at standardization. With few exceptions, little has been attempted in the way of developing the ideas under (c), that is, determining whether the characteristics

[3] Adapted from Mitchell, W. C., Index Numbers of Wholesale Prices in the United States and Foreign Countries, *Bulletin of the U. S. Bureau of Labor Statistics*, Whole No. 173, July, 1915.

shall all be treated alike or whether they shall be weighted according to their relative importance.

Just as in price index numbers, "a change in the price of sulphuric acid, for example, means more to business and industry at large than the same change in the price of hydrochloric acid,"[4] so in water supply standards or scores, a change in B. coli content may have more significance than a concomitant change in the total count. The index number, therefore, in each case should be so arranged "that the first change would affect the final result more powerfully than the second."[4] The practical development of this principle is illustrated in making the index numbers for different American industries, where "the monthly price of each commodity included in the index number was multiplied by the quantity produced in and imported into the United States, the products of these multiplications were added up separately for each month in the six years covered, and the aggregates were turned into relatives on the prewar base. Under this plan great staples like bituminous coal, yellow-pine lumber, beef and cement, which are used each year in enormous quantities, exercise much more influence upon the final results than articles like horsehair, hickory, cinnamon and bone buttons, whose combined production and imports are small."[4]

It is apparent that a similar differentiation of influence of factors upon the index number in water supply quality is a desideratum. It might be helpful, of course, to be able to weight with such exactness, as indicated in the above example of price index numbers, the B. coli content of a tap water against the objectionable sanitary conditions upon a watershed and obtain a score or index number. Attempts at such weighting have been made by some investigators. The similarity of function of the index number and the score being granted, are we justified, then, in assuming that the processes of development of the former may be or can be applied to the formation of the latter? In other words, does not the analogy between water supply scoring and the economist's index number making end with the similarity of their functions? Are sanitarians justified in carrying forward the principles of weighting beyond the recognition of their necessity?

The answer to this query will be more apparent in the further consideration of the methodology of index number making.

[4] Mitchell, W. C., International Price Comparisons, War Industries Board, *Bulletin No. 2*, pp. 2-3.

In the case of price index numbers, the object of weighting is to give each commodity included in the index number an influence upon the results corresponding to its *commercial* importance. In water supply index numbers, the object of weighting likewise is to give each factor making up the score an influence upon the results corresponding to its *sanitary* importance. The problems in the two fields are the same, but their solutions are widely different. In fact a wide-spread system of weighting the attributes of water supply quality appears impossible of development. A further comparison of the necessary processes involved in the formation of the two different index numbers should make this conclusion clearer. In price index numbers the weighting is usually a simple process of assembling similar units into aggregates. The weighting rarely, if ever, demands the conversion of dissimilar units into a composite, but presupposes in most cases such convertible units as the values of pounds and tons, and dollars. No one of the steps is dependent upon the investigator's opinion of the value of a pound of any commodity in dollars, since this conversion factor is predetermined by economic forces and not by personal judgment. It becomes possible, therefore, in such a system of weighting, for investigator A to form the same index number from a series of commodities as investigator B, since both are provided with the general equations converting the values of barrels, tons, and gallons, into dollars. The resulting figure for the index number depends, therefore, upon the choice of factors and not upon the individual's personal estimate of their relative importance.

In water supply scoring, however, the choice of factors, bacterial results, sanitary survey, operation, etc., are fairly well agreed upon, but the consideration of their relative importance remains the barrier to the successful application of index number making. This barrier seems to the author to be a permanent one, certainly as far as the national adoption of water supply index numbers is concerned, since the necessary conversion factors for the various units in a complex water supply standard are lacking. It is entirely doubtful, for instance, whether it is possible or desirable to attempt to combine the B. coli content of a tap water with the degree of excellence of filter plant operation in order to obtain an inclusive quantitative measure. The truth of this statement is apparent, when it is borne in mind that it is not logically permissible to combine incommensurables and to obtain in this way a real index number.

The author believes that any attempts to score water supplies upon a national scale by the weighting of their different sanitary characteristics fail to observe the precept that the conversion of units to a common base presupposes the absence of varying personal opinion or judgment, and the converse proposition that factors subject to differences of personal equations are incommensurable.

The above fundamental barrier, however, would appear to prevent only the use of a national standard of *complex form*. It still remains possible to make use nationally of *simplified* index numbers restricted in their range of significance and composed of similar units or, better still, of only individual units, provided the method of evaluation of such units has been definitely and completely fixed.

The latter provision has not yet been met for the country at large, but is or may be accomplished in a number of individual states, where water supplies are state controlled and, hence, where units of measurement may be made standard.

Starting, therefore, with the existence of similar methods of unit evaluation within a state, it is possible by the accumulation of basic data to institute a system of restricted or simple index numbers or measures of variation. Even in such intra-state systems, however, only comparable units can be studied, while structural, environmental, and operative features have their effect in the consideration of quality only through the qualitative judgment and experience of the student, rather than by the substitution, therefore, of a pseudo-quantitative index of doubtful significance.

In order to assist the investigator in his problem, experience data become necessary. The desirability of continued concerted study of pertinent water supply data is patent, therefore, in view of the fact that it is only by such study that basic data are accumulated to supply a knowledge of the conditions of normality. In order to illustrate such a procedure, the author has devoted the rest of this paper to the development of such data as the above. The data here reported are to serve as a guide for future studies of a *filtered chlorinated tap water in Maryland*. These restrictive limitations of the guide are used advisedly, since it may be found to vary for different classes of water supplies in the same state or for the same kind of water supply in different states. The present discussion will be restricted to only a portion of one phase of the process of simplified index number making, namely the collection, tabulation, and interpretation of the figures for a few of the characteristics of

the tap water described. An endeavor will be made to point out the significance of such a study of mass phenomena and to obtain therefrom some conclusions relative to the factors which influence index numbers or standards of quality of great simplicity.

The material on filtered chlorinated tap water here presented is an example of data which constitute one element of an index number and is material of such character that comparative data for the country as a whole may and can be ultimately obtained. In the same way, similar groups of comparative material on other simple attributes may be collected and thus will provide the bases for other comparison.

DATA FOR A SIMPLIFIED INDEX NUMBER

1. Method of tabulation and calculation. As the initial step in this study of index numbers of quality, it was determined to make use of the 1916, 1917, and 1918 figures for the 20°C. and 37°C. bacterial contents[5] of a tap water in a city in Maryland. This city was chosen because the frequency of sampling was sufficiently great to eliminate chance errors of testing, because the city has a surface water supply similar to that of a large number of American cities, which is in addition subjected to the processes of purification, rapid sand filtration and chlorination common to other water supplies. The tap waters used may be considered, therefore, in their characteristics, if not in their absolute values, typical of American cities. All of the samples to be considered in this discussion are tap samples collected daily throughout the year in various parts of the city. The average number of samples used in each temperature series is approximately 1500 in each year. Thus the total number of samples tabulated aggregated about 3000 per year, or an approximate total for the three years of 9000 samples.

In order to grasp the significance of such a record of thousands of values of variables, it was necessary to classify the observations in each series. This was done by monthly and annual series. The latter only are reported here (table 1), while the former have been omitted to conserve space. The statistical rule that class intervals should be all equal was broken, principally in order to condense an otherwise unwieldly table. The result of such a change is not

[5] 37°C, 24 hours, agar; 20°C, 48 hours, agar.

significant, when it is borne in mind that the rule has been fairly closely followed in those classes in which the major portion of the observations fall.

2. Analysis of Observations. Yule[6] describes the manner in which the observations are distributed over the successive intervals of the scale as the frequency-distribution of the variable. Too often in the past, the standards for water supplies have neglected almost

TABLE 1

Variation of bacterial content of tap water

TOTAL SAMPLES	YEAR	37°C. BACTERIA PER CUBIC CENTIMETER BETWEEN									
		0–25	26–50	51–75	76–100	101–150	151–200	201–300	301–400	401–500	501 and over
1284	1918	1036	145	28	17	14	10	13	9	1	11
		81	92	94	95.0	97.0	97.5	98.5	99.0	99.0	100.0
1562	1917	1186	159	45	44	37	29	32	13	3	14
		76	86	89	92.0	94.0	96.0	98.0	98.5	99.0	100.0
1526	1916	994	313	74	55	32	12	15	9	3	17
		65	85	89	94.0	96.0	97.0	98.0	98.5	98.8	100.0
		20°C. BACTERIA PER CUBIC CENTIMETER BETWEEN									
		0–25	26–50	51–75	76–100	101–150	151–200	201–300	301–400	401–500–	501 and over
1447	1918	998	156	48	34	31	20	34	29	9	88
		69	80	83	86.5	87.5	89.0	91.0	93.0	93.0	100.0
1541	1917	1007	136	34	49	35	33	24	24	10	191
		65	74	76	80.0	82.0	84.0	85.0	87.0	87.5	100.0
1526	1916	775	248	82	71	67	24	42	22	20	175
		51	67	72	77.0	81.5	83.0	85.5	87.0	88.5	100.0

Note.—Upper figures represent number of samples in each class, lower figures the cumulative percentages of the total number of samples.

completely the factor of frequency-distribution. Most of the standards have been concerned with averages of various kinds, neglecting the primary fact that in sanitary importance the deviations from the normal in water supplies have been almost always of more significance than the absolute normal. Typhoid fever epidemics have had their origin, in the water-borne instances, in the abnormal

[6] Yule, G. U., An Introduction to the Theory of Statistics, p. 77, Griffen & Co., Ltd.

conditions of water supplies and not in their usual. The frequency-distribution of results visualizes these important variations. For convenience of representation, the graphical presentation of the frequency-distribution is here used in addition to the tables of figures.

In order to determine the nature of the distribution of the different bacterial results in the various years studied, the cumulative values shown in the tables have been plotted in figures 1, 2, and 3. The values are plotted on the so-called probability paper developed by Allen Hazen in 1913. This paper has been ruled with lines spaced in accordance with a probability curve or according to the normal law of error. The method used in the construction of the lined sheets will not be discussed here, since it is fully described in the original contribution by Hazen.[7] It is important to note, however, that "if the data for any series correspond strictly with the normal law of error, the points plotted on this paper will all be in a straight line." An inspection of figures 1, 2, and 3 indicates at once that the tap water results for the three years in the city under discussion coincide fairly well with the normal law of error. The nature of the distribution of these results, namely the logarithmic-probability type, is entirely similar to that reported by Prof. G. C. Whipple for Philadelphia and Springfield filtered waters.[8]

3. Significance of findings. The collection and representation of a large number of tap water results as herein used make it possible to deduce certain general conclusions regarding the future study of the quality of potable waters by such regulating bodies as state departments of health. The charts shown in this paper indicate, for instance, the practical conclusion that little is lost in critical studies of water supply by using either one of the two bacterial criteria, the 20°C. or the 37°C. counts, in place of the other. The conclusion is attested by the fact that each of these has a similar mass distribution, differing one from another, only in amount and not in nature. If the investigator takes sufficient pains to determine the proper historical base for each of the indices, *by a study of past results*, it is immaterial for future control which count he uses. It is remembered, of course, that different bases are used

[7] Hazen, Allen, Storage to be Provided in Impounding Reservoirs, *Trans. A. S. C. E.*, lxxvii, p. 1539.

[8] Whipple, G. C., Element of Chance in Sanitation, *Jour. Franklin Inst.*, vol. 182, no. 1, July, 1916.

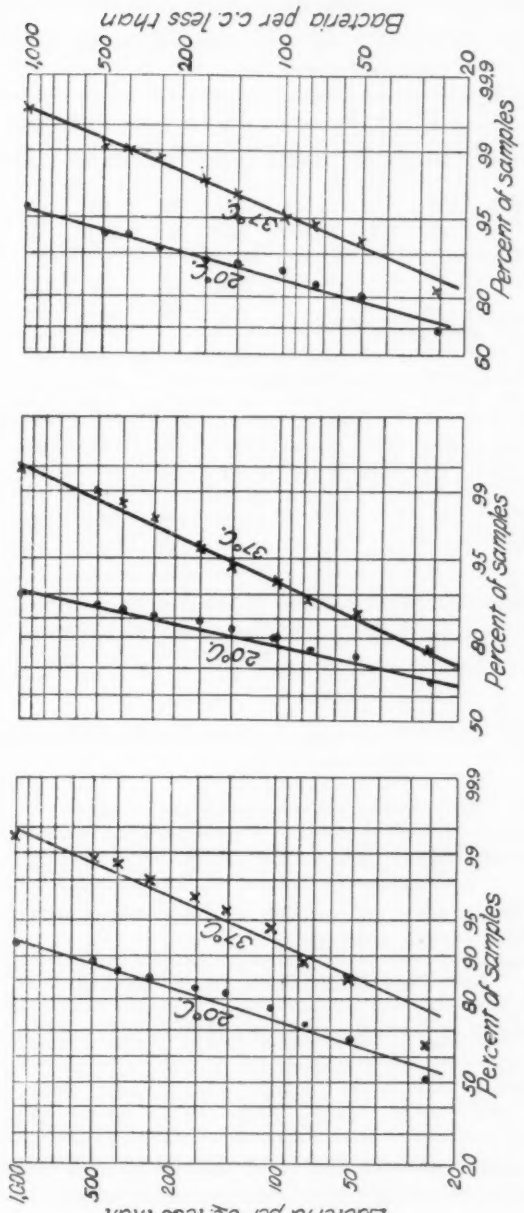


FIG. 1, 1916

FIG. 2, 1917

FIG. 3, 1918

FREQUENCY-DISTRIBUTION RECORDS OF BACTERIA IN FILTERED AND CHLORINATED WATER

TABLE 2

Variation of bacterial content of tap water. Corrected values for use in standard quality sheet

TOTAL SAMPLES	YEAR	37°C. BACTERIA PER CUBIC CENTIMETER BETWEEN								
		0-5	6-10	11-15	16-20	21-25	26-50	51-75	76-100	101-150
952	1918	372	237	97	54	30	89	16	13	11
		39	64	74	80	83	92	94.0	95	97
						(0-25)				
1449	1917					1164	151	35	26	19
						80	90	93.0	95	96+
		20°C. BACTERIA PER CUBIC CENTIMETER BETWEEN								
		0-5	6-10	11-15	16-20	21-25	26-50	51-75	76-100	101-150
1050	1918	405	185	102	73	33	109	24	21	11
		39	56	66	73	76	86	89.0	91	92
						(0-25)				
1272	1917					925	125	33	37	25
						73	83	85.5	88	90

Note.—Upper figures represent number of samples in each class, lower figures the cumulative percentages of the total number of samples.

TABLE 3

Variation of bacterial content in raw water. 1917 and 1918 corrected cumulative values and percentages

TOTAL SAMPLES	37°C. BACTERIA PER CUBIC CENTIMETER BETWEEN								
	0-500	501-1000	1001-5000	5001-10000	10001-15000	15001-20000	20001-30000	30001-40000	40001-50000
508	0	348	479	497	500	503	504	505	506
	0	70.0	95.8	99.4					
	20°C. BACTERIA PER CUBIC CENTIMETER BETWEEN								
	0-500	501-1000	1001-5000	5001-10000	10001-15000	15001-20000	20001-30000	30001-40000	40001-50000
509	0	104	331	371	394	412	432	443	457
	0	20.8	66.2	74.2	78.8	82.4	86.4	88.6	91.4

Note.—Upper figures represent number of samples in each class, lower figures the cumulative percentages of the total number of samples.

for comparison and, with these established, it becomes relatively easy to measure changes of quality in extended series by either one of the significant counts. The graphical procedure makes it possible also to check the findings in the one series of results with the corresponding findings at the other temperature. Here, again, the precaution of obtaining the proper preceding series for comparison must be observed.

In order to obtain a future guide for the study of the quality of a filtered chlorinated water, it was necessary to correct the values

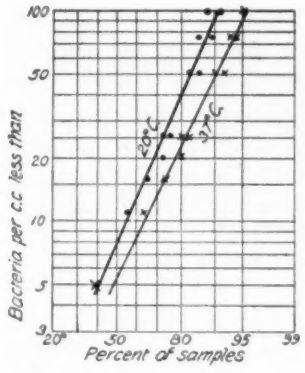


FIG. 4. ALLOWABLE FREQUENCY-DISTRIBUTION OF BACTERIA IN FILTERED AND CHLORINATED MARYLAND WATER

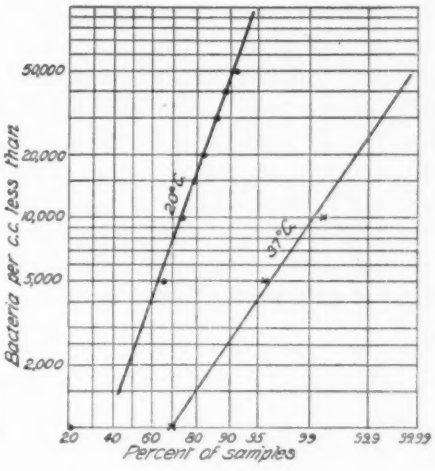


FIG. 5. FREQUENCY-DISTRIBUTION OF BACTERIA IN RAW WATER DURING 1917 AND 1918

shown in table 1, so as to eliminate bacterial results definitely established as due to inavoidable faulty conditions of operation or to unexpected temporary, but necessary, changes in source of supply. For the purpose of developing a base for comparison of future 20°C. and 37°C. counts, it was decided to eliminate the results obtained during 1916 and several months in 1917 and 1918. This was done to permit the use of bacterial results in a tap water during periods of normal operation, but excluding "tuning up" of purification processes, intervals of chemical shortages, and temporary changes in sources of supply subject to inadequate purification.

The revised list of data for the development of a filtered chlorinated water guide-post to be used in Maryland, is shown in table 2 and in figure 4, which serves as the "standard quality sheet," to be used for basic long period studies of the supplies similarly treated.

An inspection of the "standard quality sheet" for a filtered chlorinated water in Maryland indicates, for instance, that the median bacterial count in the tap water is about 6 for the 37°C. count and about 8 for the 20°C., while 95 per cent of the tap waters, in the series studied, show 37°C. counts less than 100 and 90 per cent indicate 20°C. counts less than 100 per cc. It is of interest to recall that Francis F. Longley in 1916 was reported to have found that "in well ordered filter plants the median bacterial count for the filtered water is usually less than 20 per cubic centimeter, while during 95 per cent of the time the bacterial counts are less than 100 per cubic centimeter."[8] It would be desirable, for purposes of judgment in control of various water supplies, particularly those under state supervision, to have more complete statistical data like the above from various parts of the country. For purposes of comparison, the bacterial load carried by the plant from which the above data were collected is shown on figure 5 and in table 3.

INVESTIGATION OF QUESTION OF FLANGES FOR LIGHT CAST IRON PIPE[1]

By John Knickerbacker

The question of flanges for light cast iron pipe has come up for discussion at different times, but up to now no final action has been taken. The American Society of Mechanical Engineers at its meeting on December 3 to 6, 1918, received a report from its committee on light flanges, in which report a "proposed low-pressure standard for end flanges, bolting and body thicknesses—50 pounds working pressure" is given.

The flanges proposed for 50 pounds working pressure by the American Society of Mechanical Engineers are of the same thicknesses and diameters and have the same diameters of bolt circles and the same number of bolts as the American Standard Flanges for 125 pounds steam working pressure; but the bolts are of smaller diameters than the sizes used in the American Standard Flanges for 125 pounds steam working pressure. The American Standard Flanges for 125 pounds working pressure became effective January 1, 1914, through the recommendation of the American Society of Mechanical Engineers.

It is surely desirable to arrive at some standard or standards as soon as possible for light flanges, provided the standard or standards would meet with the approval of the engineers, the users, and the manufacturers of cast iron pipe, valves, and fittings. To bring this to the attention of this Association and those interested in this question, figures 1 to 12 show in full size the thicknesses of pipe and thicknesses of flanges for American Water Works Association classes A, B and C pipe, the flanges for these pipes being calculated by the formula, thickness of flange equals one and one-half times thickness of pipe, plus one-eighth of an inch; the thicknesses of pipe of the American Gas Institute, and the thicknesses of flanges and bolt circles adopted by it; the American Society of

[1] Read at the Buffalo Convention June 10, 1919.

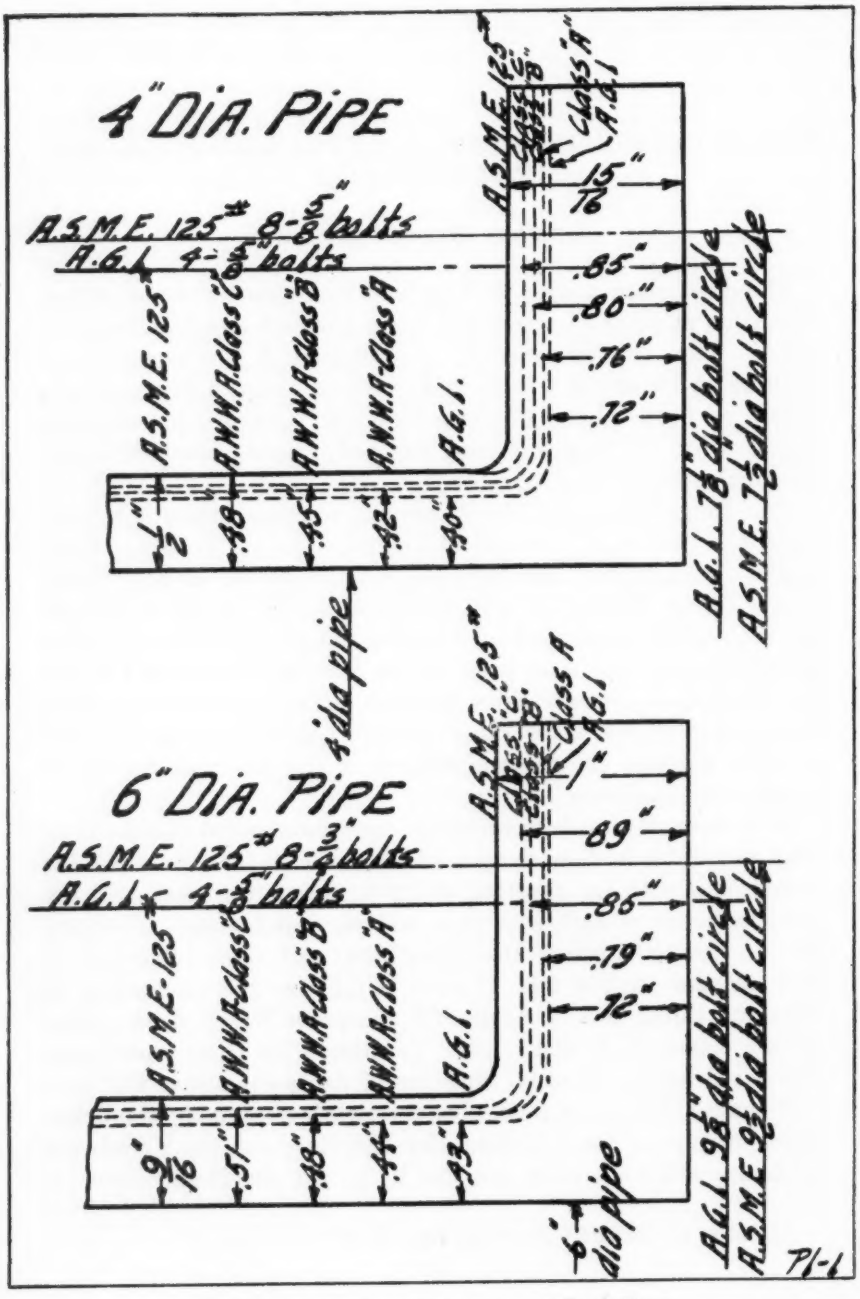


FIG. 1. FLANGES FOR 4-INCH AND 6-INCH PIPE

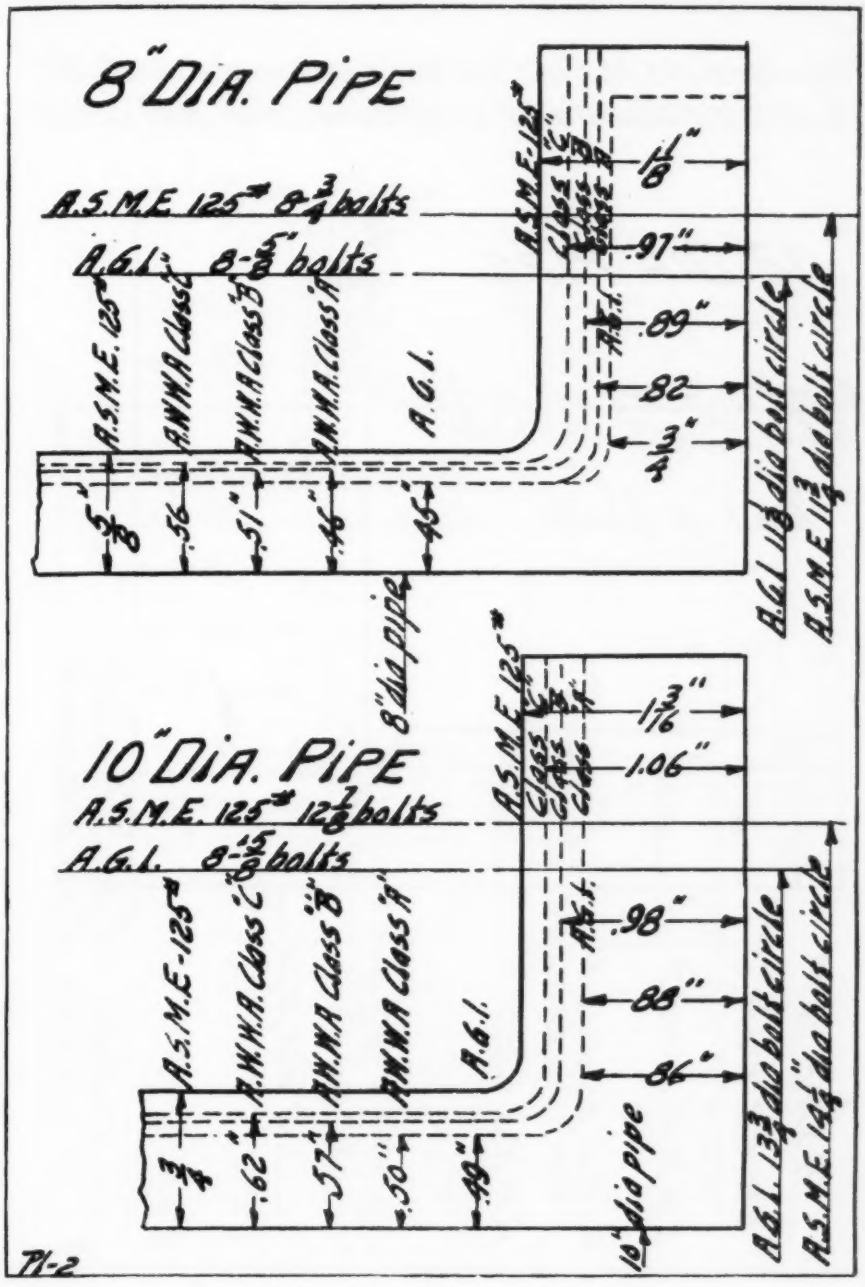


FIG. 2. FLANGES FOR 8-INCH AND 10-INCH PIPE

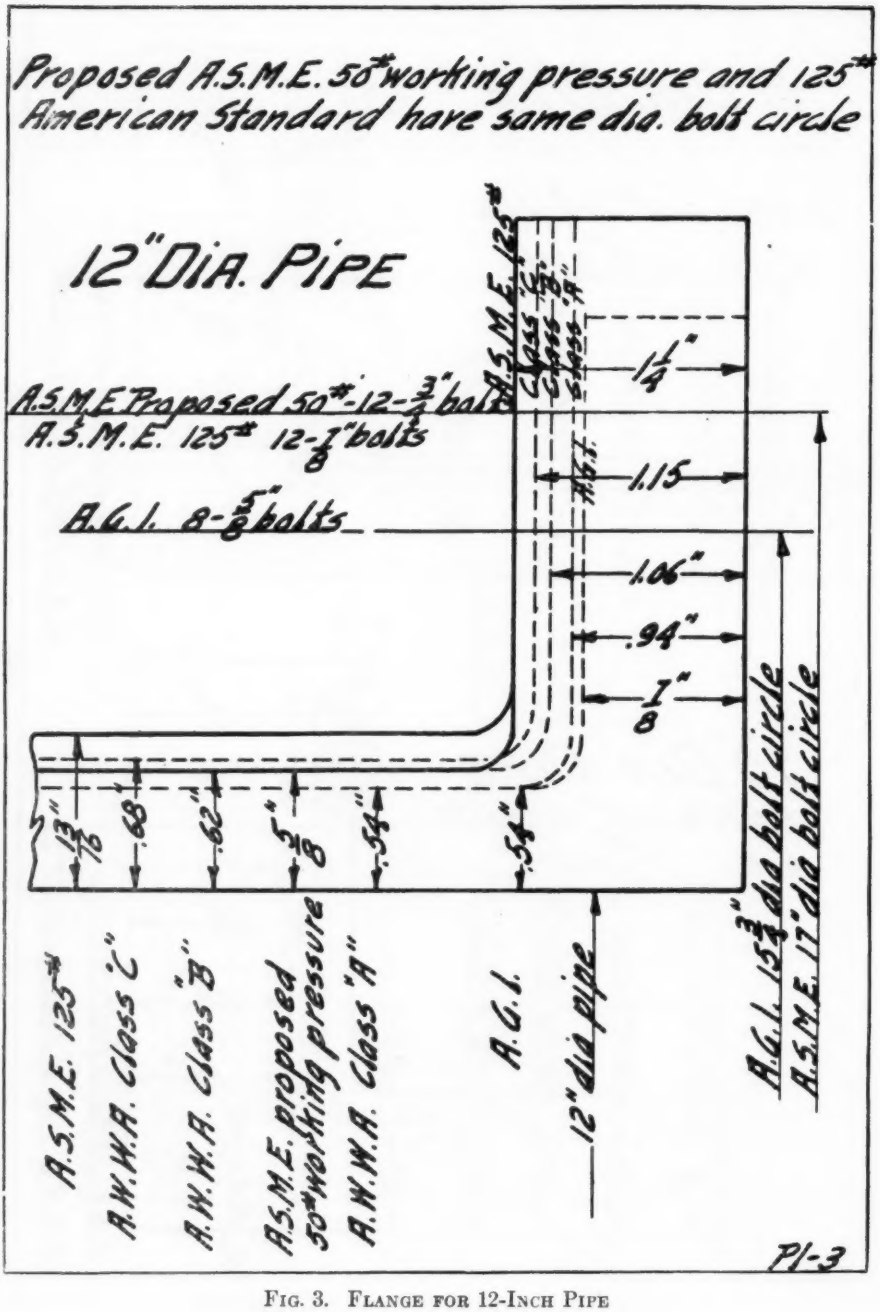


FIG. 3. FLANGE FOR 12-INCH PIPE

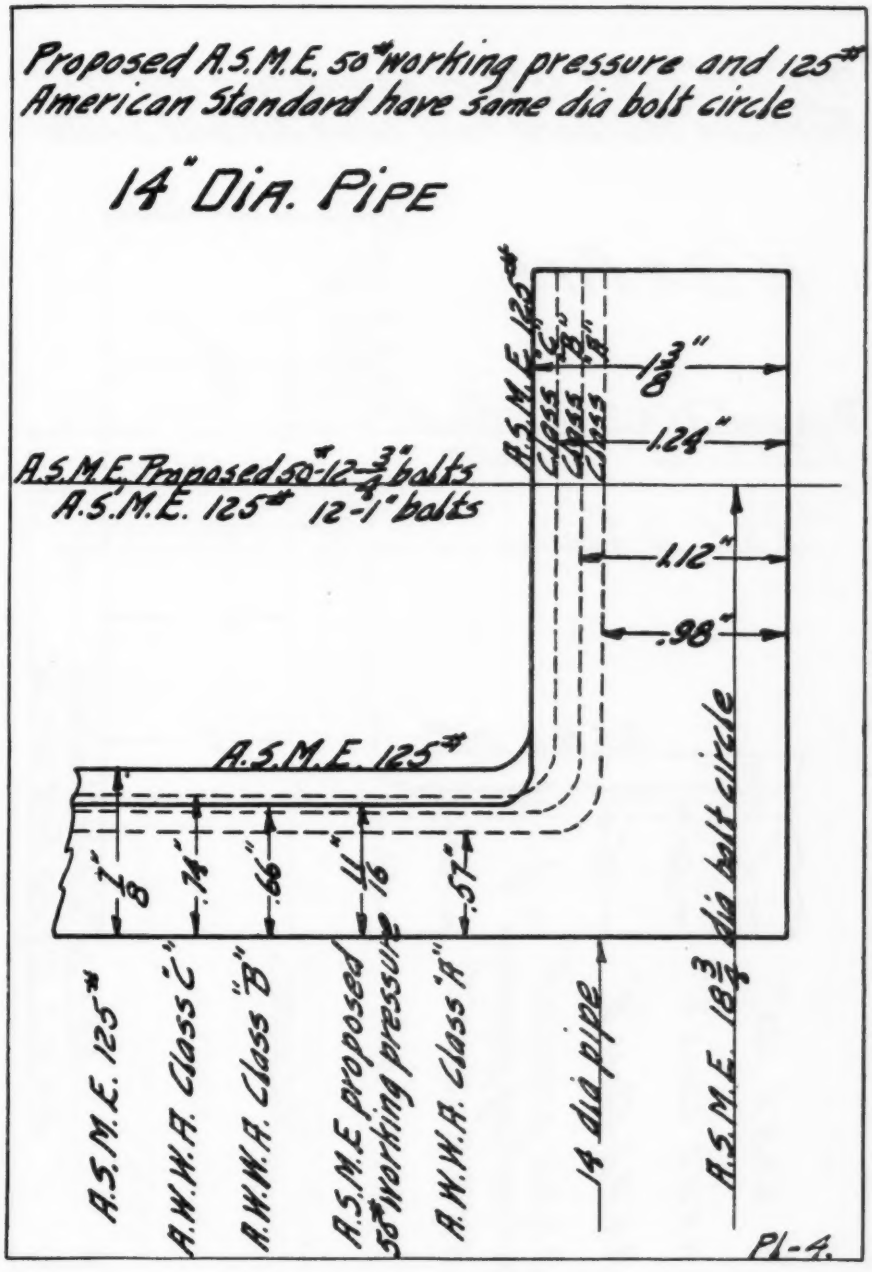


FIG. 4. FLANGE FOR 14-INCH PIPE

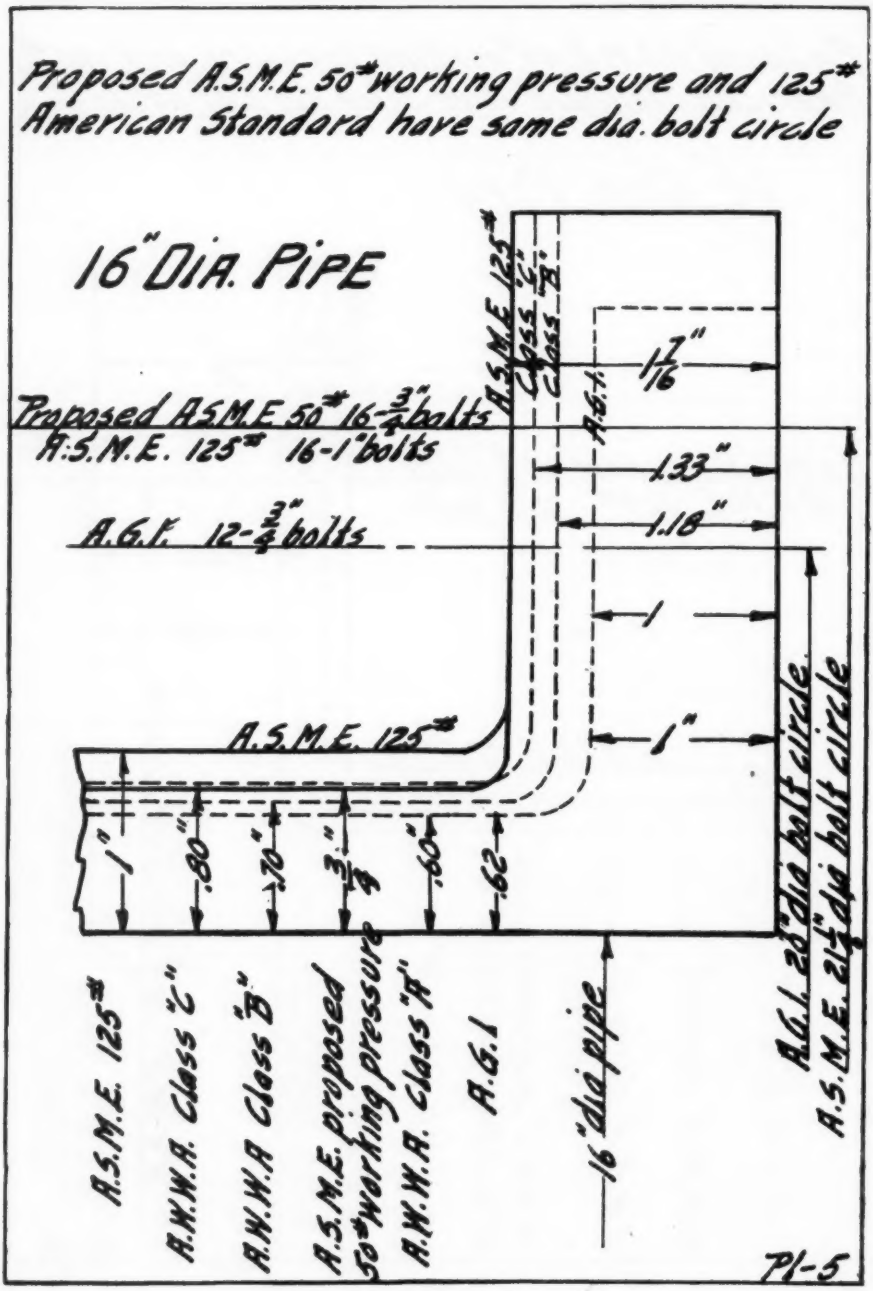


FIG. 5. FLANGE FOR 16-INCH PIPE

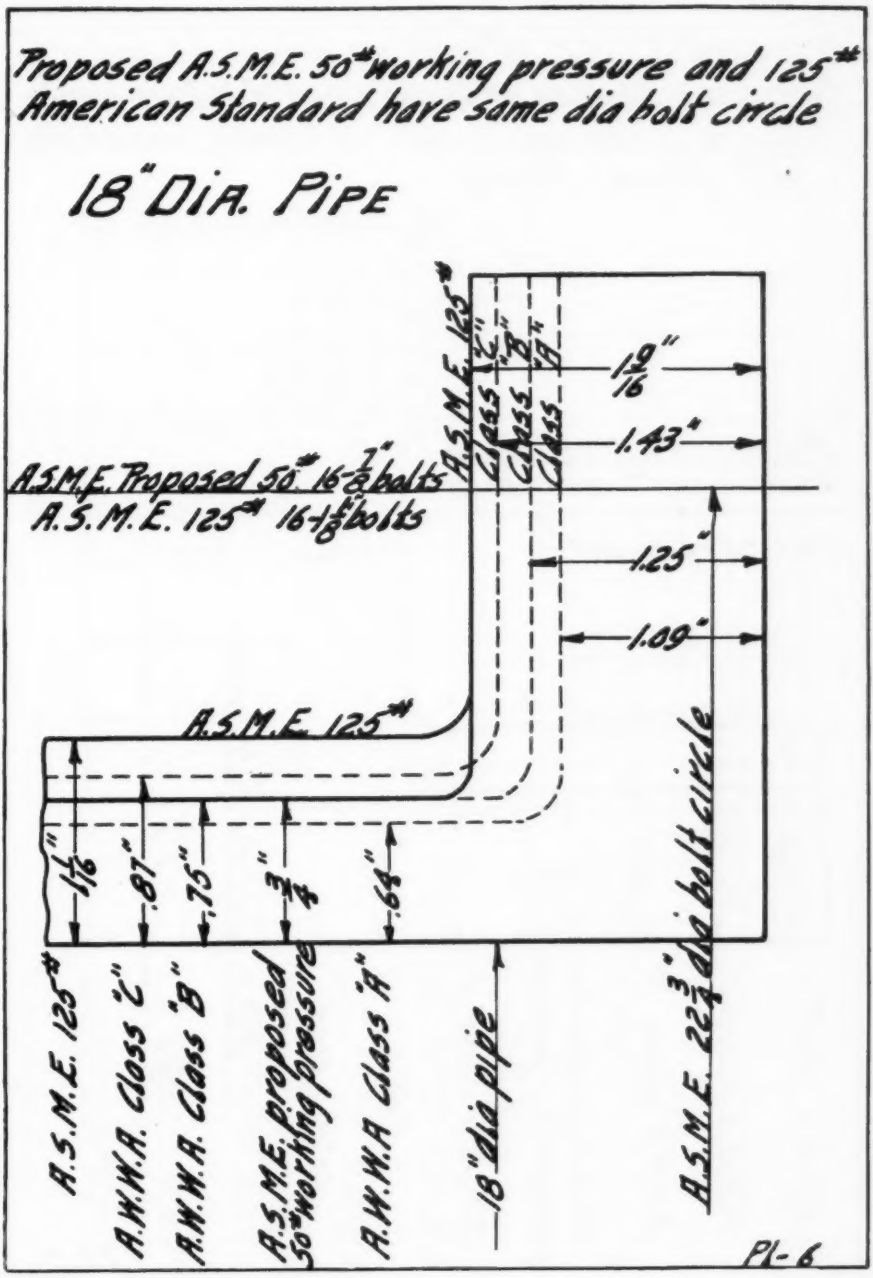


FIG. 6. FLANGE FOR 18-INCH PIPE

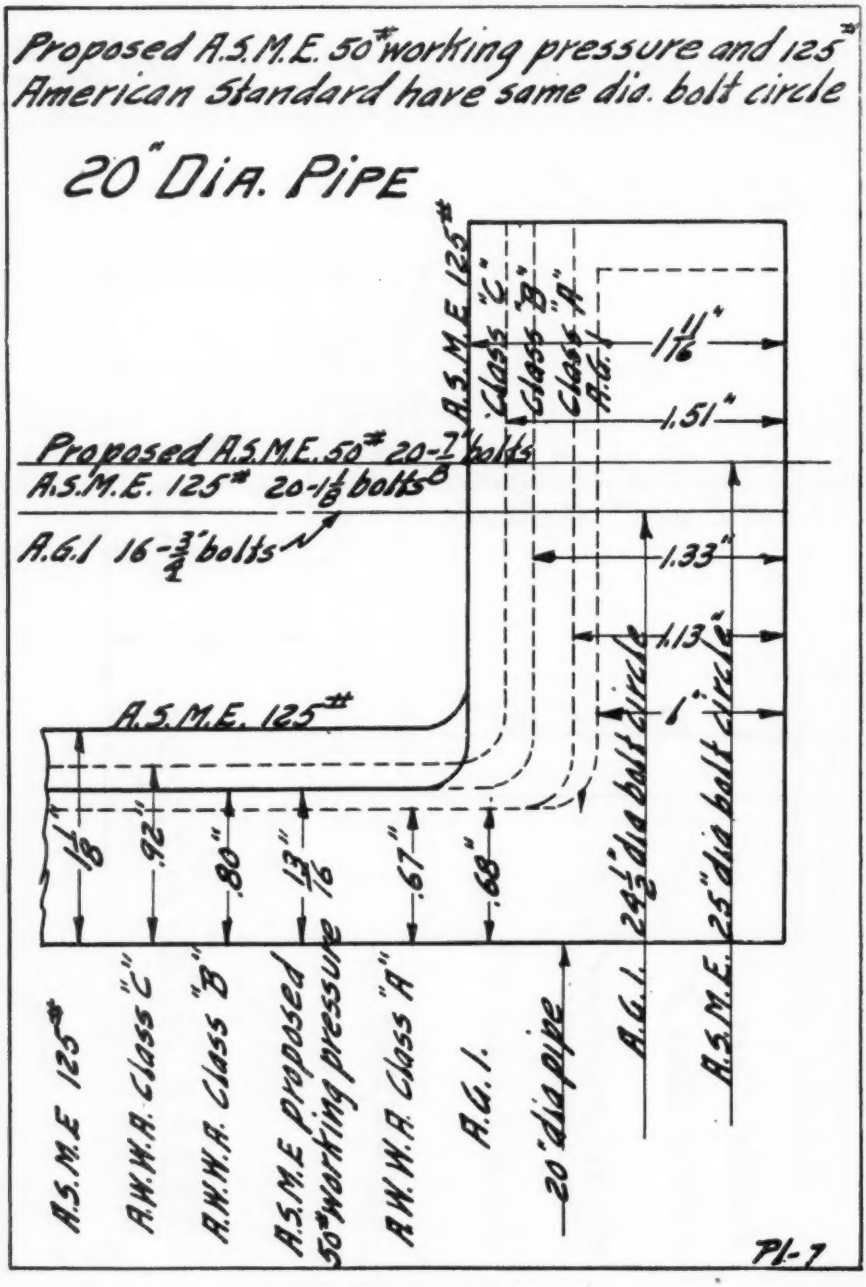


FIG. 7. FLANGE FOR 20-INCH PIPE

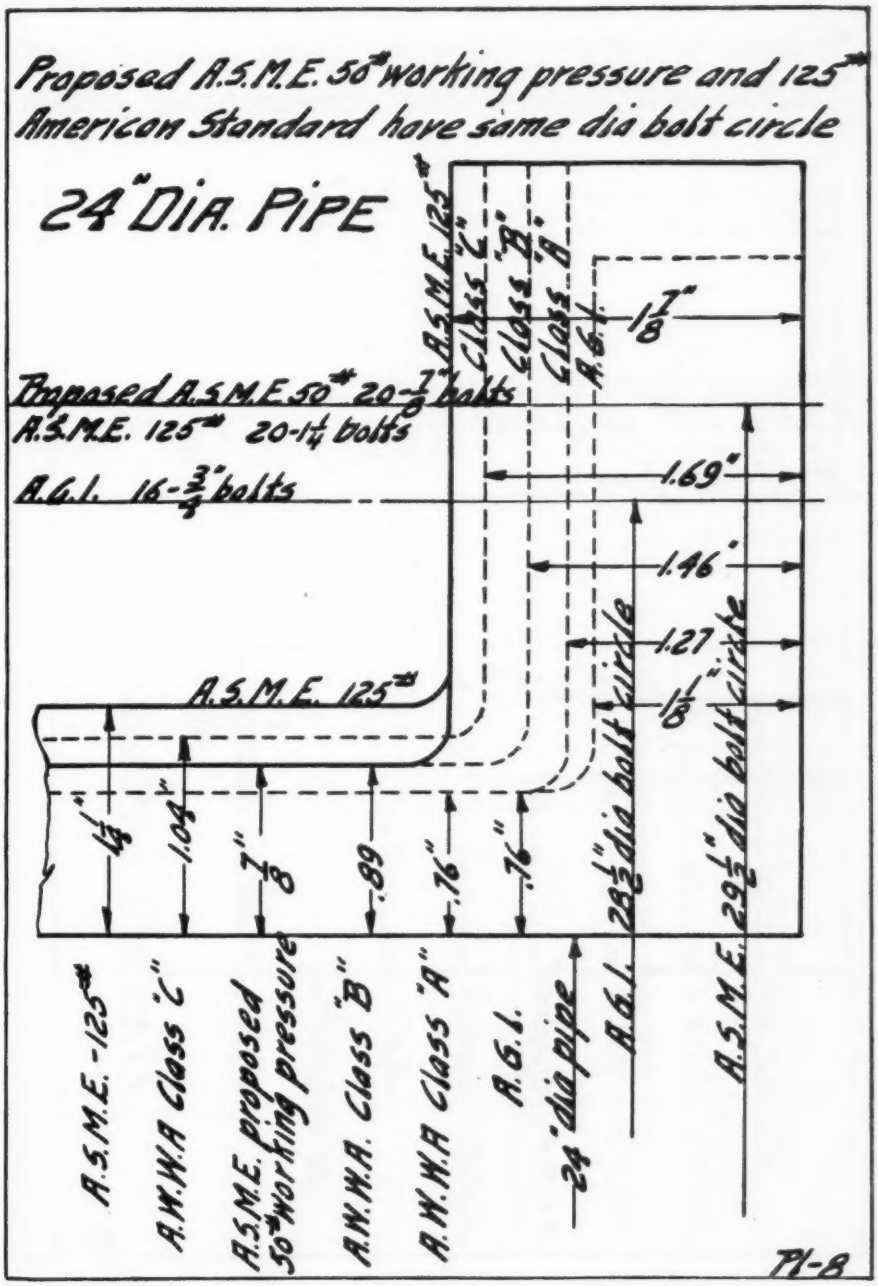


FIG. 8. FLANGE FOR 24-INCH PIPE

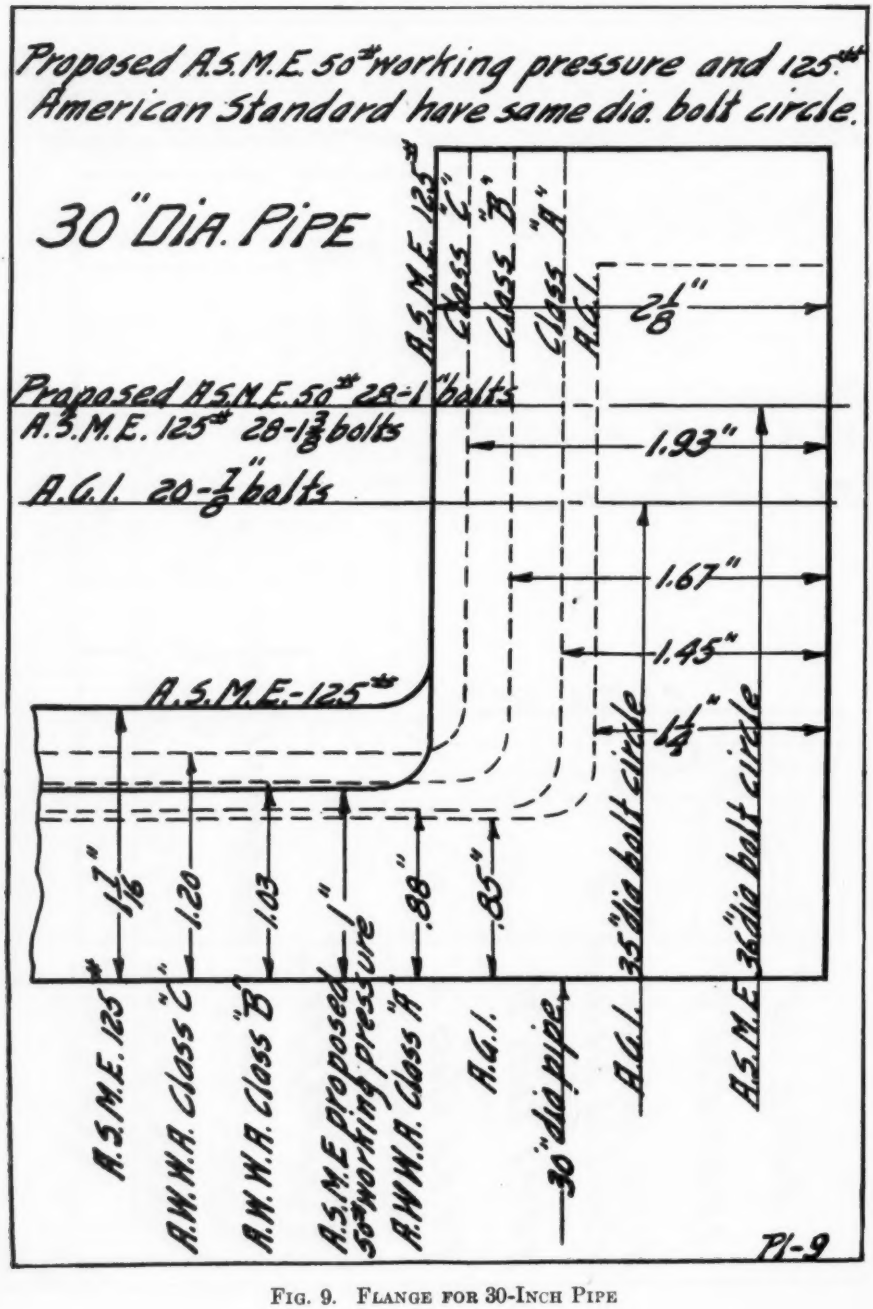


FIG. 9. FLANGE FOR 30-INCH PIPE

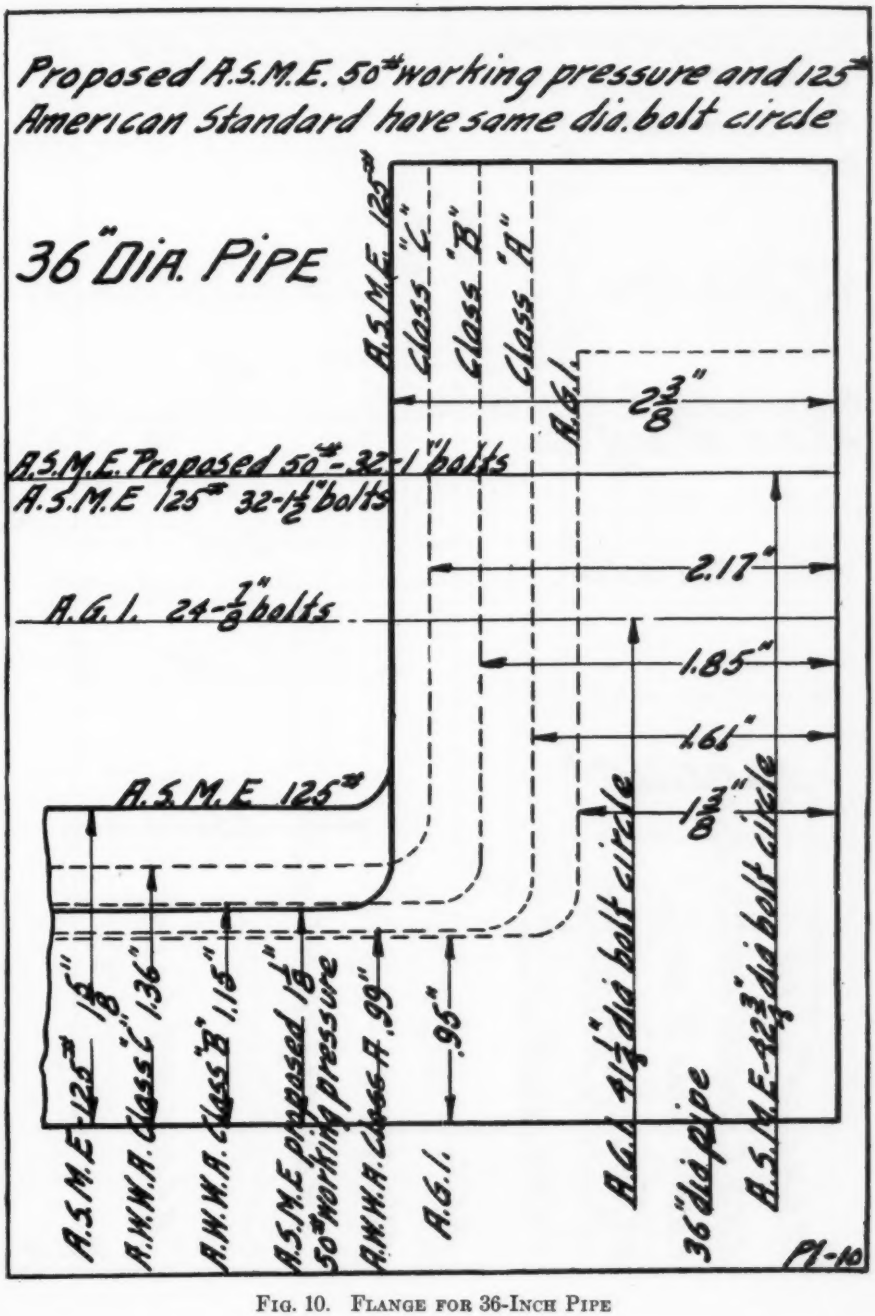


FIG. 10. FLANGE FOR 36-INCH PIPE

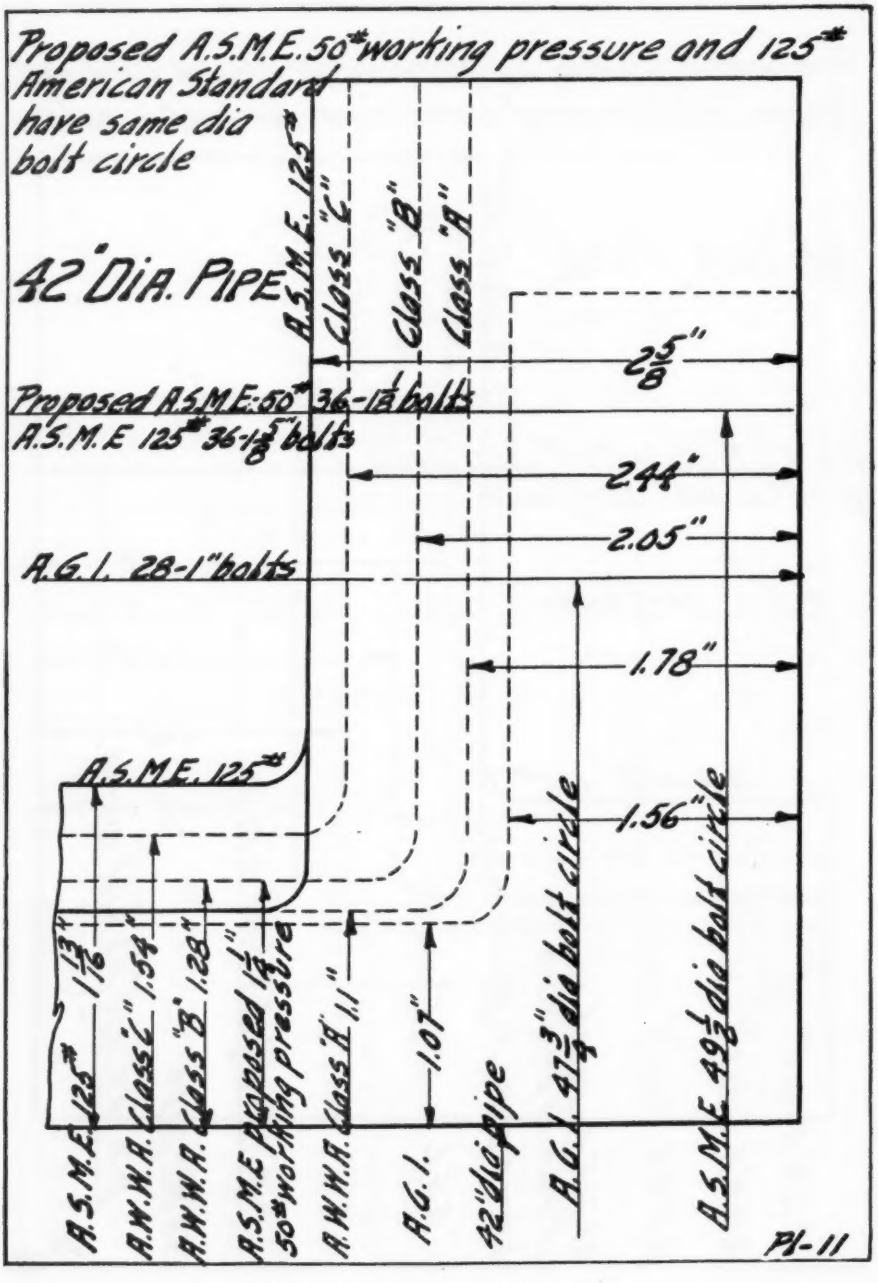


FIG. 11. FLANGE FOR 42-INCH PIPE

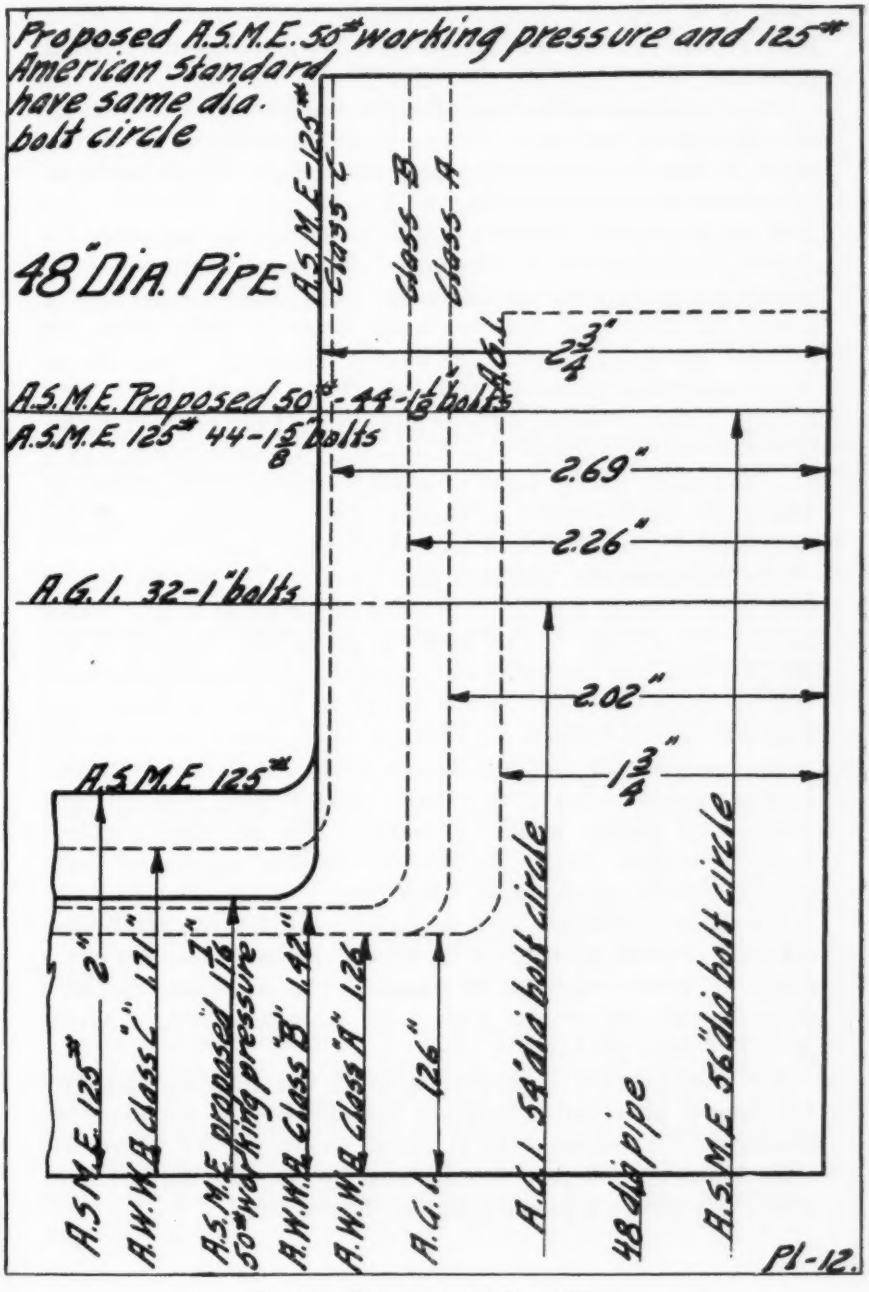


FIG. 12. FLANGE FOR 48-INCH PIPE

Mechanical Engineers proposed standard for 50 pounds working pressure, and the American Standard for 125 pounds steam working pressure.

These layouts visualize comparatively the different standards for each size shown and serve to bring to the attention of the person studying them the comparative proportions of the flanges and pipe thicknesses of the sizes largely used.

There is a serious question if the standard flange suggested by the American Society of Mechanical Engineers for pipe for 50 pounds working pressure is not too heavy and will not cause casting strains and shrinkage where the flange meets the pipe. Take, for example the 30-inch pipe. The class A, American Water Works Association pipe measures 0.88 inch thick. Would it be good foundry practice to cast a flange measuring $2\frac{1}{8}$ inches thick to this thin pipe, and if the pipe were increased in thickness about $\frac{1}{8}$ inch to 1 inch thick, the thickness proposed by the American Society of Mechanical Engineers for 50 pounds working pressure, would not the flanges $2\frac{1}{8}$ inches thick be too heavy for the pipe?

The American Gas Institute pipe thickness for 30-inch pipe is 0.85 inch. Taking the inside diameter of the flange at 31.7 inches on this 30-inch pipe, as 31.7 inches is the outside diameter of the pipe, the weight of the American Gas Institute flange is 102.4 pounds and the flange proposed by the American Society of Mechanical Engineers for light pipe is 215.5 pounds which is over twice as much as the American Gas Institute 30-inch flange. If the American Gas Institute flange is heavy enough for class A pipe, then for each flange 113.1 pounds would be wasted if the American standard flange were used; besides the poor casting that might result from casting such a heavy flange on a light pipe.

If a flange 1.67 inches thick were used on a 30-inch class B pipe, taking the outside diameter of the pipe as the inside diameter of the flange, it would weigh 169.38 pounds. The American Standard flange on this pipe would weigh 215.5 pounds, showing a saving of 46.12 pounds per flange.

If it were possible to use the American Gas Institute flange for the class A pipe, and a flange of the diameter of the American Standard, but between the thickness shown for the flanges for class A and class B pipe as calculated by the formula previously given, it might be a good solution of the question.

Would it not be a good idea for the Committee of this Association which has this matter in charge, to endeavor to take it up with like committees from the New England Water Works Association, the American Society of Mechanical Engineers, the American Gas Institute, the Cast Iron Pipe Manufacturers, the Committee of Manufacturers on Standardization of Fittings and Valves, and such other organizations as might wish to be represented? Is not this a question that should be settled as soon as possible by the representatives of all the parties concerned?

It is hoped that the line cuts which form part of this paper will prove of interest.

DISCUSSION

D. W. FRENCH: It is to be assumed that this question of flanges for light cast iron pipe has reference to water pipe to be laid in the ground. The speaker is in doubt about the advantage of flanged cast iron pipe for such purposes. Flanged pipe not only costs more than bell and spigot pipe but its use involves a special hazard where the main is under a pressure of 50 pounds or more. Many of us have had experiences with the settling of cast iron mains, which tends to cause leaking joints. If light cast iron flanged pipe settled the distortion might easily increase materially the 50 pounds working pressure to which parts of the metal would be subject, and hence there is a question as to the wisdom of using it.

W. H. RANDALL: The author recommends that this Association take up with other organizations this subject of standardization of cast iron flange pipe, which is a wise thing to do. It is absolutely necessary at times to use flange pipe, and a standardized pipe of this type will be helpful in obtaining prompt deliveries of a reliable product.

JOHN KNICKERBACKER: The paper does not refer exclusively to flanges for pipe laid in the ground but covers all cases of flanged pipe. There is a manufacturers' committee on specifications for valves and fittings which has gone into this matter very carefully. The committee includes representatives of about forty makers of pipe and fittings, and it seems appropriate that it should be consulted in reference to this subject. The purpose in presenting the

paper was to give the members definite information on the present status of the subject, so that any action taken might be based on a knowledge of what had been accomplished toward standardization to date.

PRESIDENT HENDERSON: The Association now has a committee on the revision of standard specifications for cast iron pipe and specials, which is working in coöperation with a similar committee of the New England Water Works Association and with manufacturers of pipe. The subject is one which falls within the scope of the work of that committee, and the paper is therefore referred to that committee for its consideration.

COST OF WATER MAIN CONSTRUCTION IN MASON CITY, IOWA[1]

By W. A. Judd

In 1915 and 1916, labor was plentiful with the Mason City Water Company at 22½ cents per hour. In 1917 and 1918 it was scarce at any price and part of the time the company had only its emergency crew of five men to work with. Consequently a fair comparison of the costs during the two periods can scarcely be made. So many things influence the cost of construction that each job must be considered by itself. For instance, in 1915, a half-mile stretch of 10-inch pipe was laid in good clay digging, with some shale. The weather was hot and the laborers, except the pipe gang, were not working up to usual efficiency. The earth excavation costs ran up to 37 cents per cubic yard, loose rock 88 cents, back filling 11 cents, and the 10-inch pipe only cost 5 cents per foot to lay. Part of this low laying cost is due to the fact that the ditch stood up well, and 500 or 600 feet would be laid in one day. Contrast this laying cost with another job the same year, which was scattered in little bits for half a mile, laying intersections preparatory to paving. The laying cost here for 6-inch pipe was 7 cents per foot, but excavation prices were lower than on the longer job, no doubt due to the cooler weather which prevailed. In 1916, one block of 10-inch pipe laid in a rock ditch a little at a time cost 16 cents per foot with labor at 22½ cents per hour. On this job, the cost of back filling jumped to 22½ cents due to the rock present. On another very similar job in 1915 a large amount of rock made the cost of back filling run up to 24½ cents per cubic yard.

In 1915, a string of 8-inch pipe was laid in sandy clay during hot weather. Earth excavation cost 32 cents per cubic yard; back filling 13 cents per cubic yard, and laying 3.7 cents per foot. A similar job in 1916, when a new pipe gang was broken in, showed earth costs 40 cents, back filling 16 cents and pipe laying 7.7 cents. During

[1]Read before the Iowa Section, April 16, 1919.

very hot weather, that year, a string of 8-inch pipe was laid following a trenching machine at a cost of 7.1 cents per foot. The same pipe gang followed the same machine with a string of 10-inch pipe for 7.8 cents per foot, and another string of 10-inch pipe, in caving clay and under rather difficult circumstances, for 8.9 cents per foot.

The influence of weather and soil conditions is shown very well in some 6-inch jobs following this machine. One job in wet, sticky clay cost 8.9 cents per foot. Bracing was needed here right behind the machine. Another job in wet clay but with weather conditions more favorable cost 6.4 cents per foot, while in a good clay ditch with favorable weather the cost ran 4.0 cents and with the best weather of all, 6-inch pipe laid in a sandy ditch only cost 3.2 cents per foot. In 1917, with a small gang at 30 cents per hour, earth excavation cost close to 42 and 47 cents on two representative jobs. A little rock in one caused back filling to cost 16 cents, while the other cost 12½ cents. Pipe laying on these jobs ran about 7 cents per foot, which was approximately the cost also of laying pipe in a rock ditch dug by contract.

In 1918, cost keeping did not amount to much, so far as any comparative value of the records is concerned. Earth costs varied from 42 to 66 cents and rock excavation in small quantities went as high as $5.50 per cubic yard. The cost of pipe laying was very consistent, however, being nearly 8½ cents per foot for 6-inch pipe on all jobs. The old, dependable emergency gang was responsible for keeping the pipe laying price so reasonable. Perhaps more stable labor conditions will make cost keeping a profitable investment this year; it certainly did not amount to anything last year. During the previous years, however, similar conditions produced similar results and labor costs could be predicted with reasonable accuracy.

THE GALLERY COLLECTING SYSTEM OF THE DES MOINES WATER COMPANY, DES MOINES, IOWA[1]

By A. T. Luce

The Des Moines Water Company is one of the pioneers, if not the first, to develop its water supply thoroughly by means of infiltration galleries. A number of cities have water supplies developed from underlying sand and gravel strata by means of wells but few, if any, have adopted the method used here. In order to understand the practical application of this method, it will be necessary first to fix clearly in mind the fundamental features of the water-bearing area, before undertaking to follow through the various stages of its development.

The water is obtained primarily from the Raccoon River. This stream lies in a southwesterly direction from Des Moines and discharges into the Des Moines River in the heart of the city. It has a drainage area of 3677 square miles above the city and a minimum flow of sufficient quantity to more than meet the needs of the city for years to come.

The most interesting feature of the river, from a water supply standpoint, is the geology of its valley in the vicinity of Des Moines. Here we find a broad valley, nearly 100 feet deep and a mile wide, which has been eroded in the clay, shale and rock of the natural topography and extending for many miles upstream with relatively steep sides, terminating in rolling plains above. It is evident that this valley was eroded by a preglacial stream which eventually cut its way to a hard bottom and later covered this bottom with clean sand and fine gravel brought down from the glaciers, and then, at a still later period, covered this gravel bed with from 5 to 10 feet of alluvium. As might be expected, this stratum of sand and gravel terminates at the foothills on either side but extends upstream for many miles. Borings have shown this to be true and many made by the Water Company affirm the fact that it is from 10 to 30 feet in thickness, very clean and uniform in size. An analysis of the bor-

[1] Read before the Iowa Section April 16, 1919.

ings shows no marked difference in the character of the material although in some places the sand predominates while in others the gravel. There is, however, little difference in the water-carrying capacity, the average effective size being about 0.42 mm., with a coefficient of uniformity of 4.00.

Owing to the fact that the surface of the valley lies below the level of the flood plane of the river, it is sparsely settled both within the city and for a long distance above it. Thus we find extending right in the city a large sand- and gravel-filled basin, sealed off from practically all outside contamination by the topography and the natural clay soil, through which meanders a river of ample size to furnish the water requirements for many years to come. During the greater portion of the year, this river is low in turbidity but it is subject to floods that periodically scour the silt deposits from its bed.

It was concluded early in the development of the Water Company that the sand of the river would act as a good filtering agent, and there was accordingly constructed in 1871 a steel tank 21 feet in diameter and 14 feet high, with perforated sides and closed top. This tank was sunk in the gravel on the south bank of the river until its top was 10 feet below low water and it was surrounded with coarse gravel. It has been estimated that this tank furnished water at the rate of 1,500,000 gallons per day for short periods. A direct river inlet was later connected for emergency use. In 1876 two more tanks were installed on the north bank of the river. These were similar to the original, being 12 feet in diameter and 12 feet high, with perforated sides and open bottom but having tops constructed of 12 by 12 inch timbers.

The first unit of the present collecting system was built in 1882. This was the suction well located in the station yard and approximately 800 feet from the river. It consists of a brick-lined well 50 feet in diameter and 35 feet deep, with walls 19 inches thick resting on an iron shoe. The well is roofed over below the ground and contains the suctions of the pumping engines. The top of the well is about 15 feet above the normal river level. Upon completion the well was capable of delivering 500,000 gallons per day. With this well and the three boxes a supply of from 2,000,000 to 3,000,000 gallons per day was obtained, although the draft upon the boxes was beginning to draw sand into the pumps and give more or less trouble.

In 1884 work was started on the first gallery. This gallery is known as the No. 1 gallery and extends, as shown in figure 1, from the suction well south under the tracks of the Rock Island railroad a distance of 260 feet, thence in a westerly direction along the railroad between it and the river for a distance of 817 feet, terminating at a point 150 feet from the river bank. It is 4 feet high by 5 feet wide and surrounded with 1 inch screened stone, as shown in figure 2. The bottom is open and the sides and top are made of 3 by 6-inch white elm timbers laid with $\frac{3}{8}$ inch spaces between. The gallery was built in open cut, the ditch varying from 17 to 27 feet in depth. It was completed in 1886.

The old iron tanks were abandoned in 1885 and the water drawn entirely from No. 1 gallery and the suction well. Thus we find that 34 years ago the entire water supply was developed by infiltration at a considerable distance from the river.

Owing to the steady growth of the city and the increasing demand for water the No. 2 or river gallery and river well were built in 1887. The well was located in the station yard and is 20 feet in diameter by 30 feet deep built with 20-inch brick walls resting on a wooden shoe. It is roofed over with brick arches supported by I-beams. In order to prevent wash from the gallery one-half of the bottom is floored with a baffle in the center. This gallery is 1994 feet in length and lies along the foot of the bluff on the north side of the railroad, terminating in an emergency inlet to the river. Like the No. 1 gallery, it is constructed of white elm timbers in open cut varying in depth from 15 to 30 feet. It is smaller, however, in size being only 4 feet wide by 4 feet 2 inches high with open bottom and tightly sheeted sides and top made of 4 by 6-inch white elm timbers set on a bed of screened broken limestone. At the time of completion of this gallery, there was ample infiltration to supply the domestic and fire demand of the city without recourse to the emergency river intake, the average daily consumption being about 2,000,000 gallons.

It was not necessary to augment this supply by additional galleries until 1894, when the consumption had increased to an average of nearly 3,000,000 gallons per day. During this year the No. 3 gallery was constructed. This gallery is an extension of the No. 1 gallery, beginning at the end of the old gallery and extending across the river and upstream parallel to it for a total distance of 1250 feet. It is 3 feet 8 inches high by 5 feet wide and was built with sides of 4 by 6-inch timbers in which $\frac{1}{4}$ inch spaces were left between timbers.

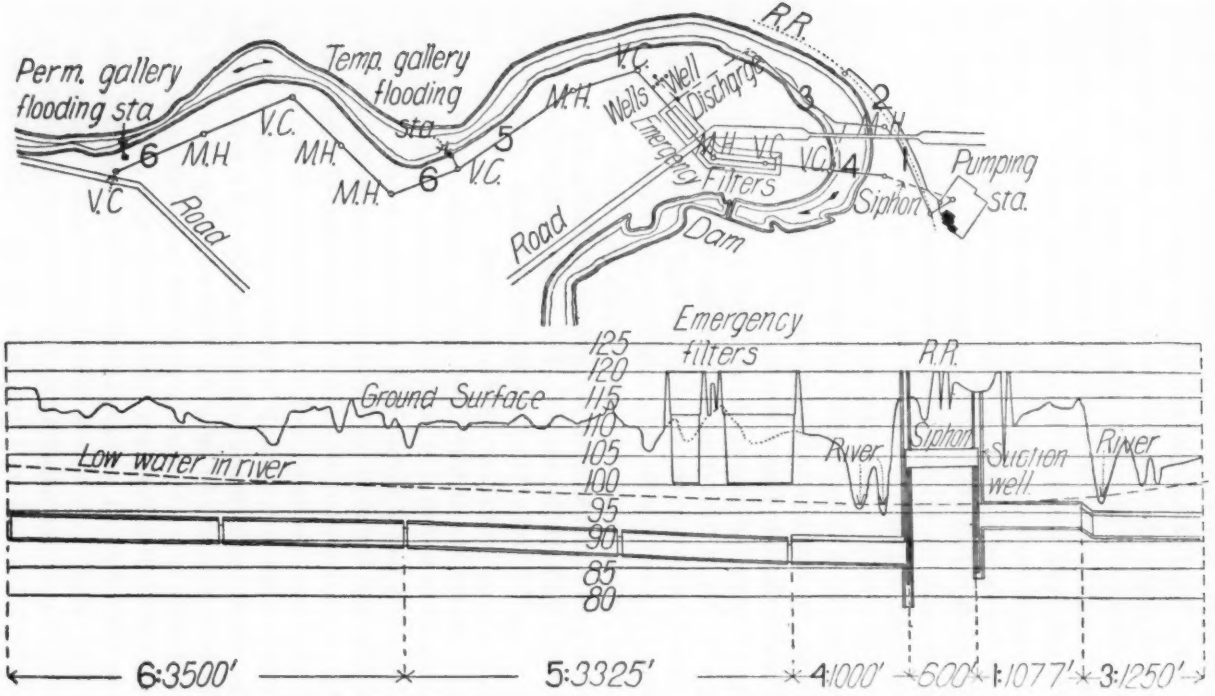


FIG. 1. THE GALLERY COLLECTING SYSTEM OF THE DES MOINES WATER COMPANY

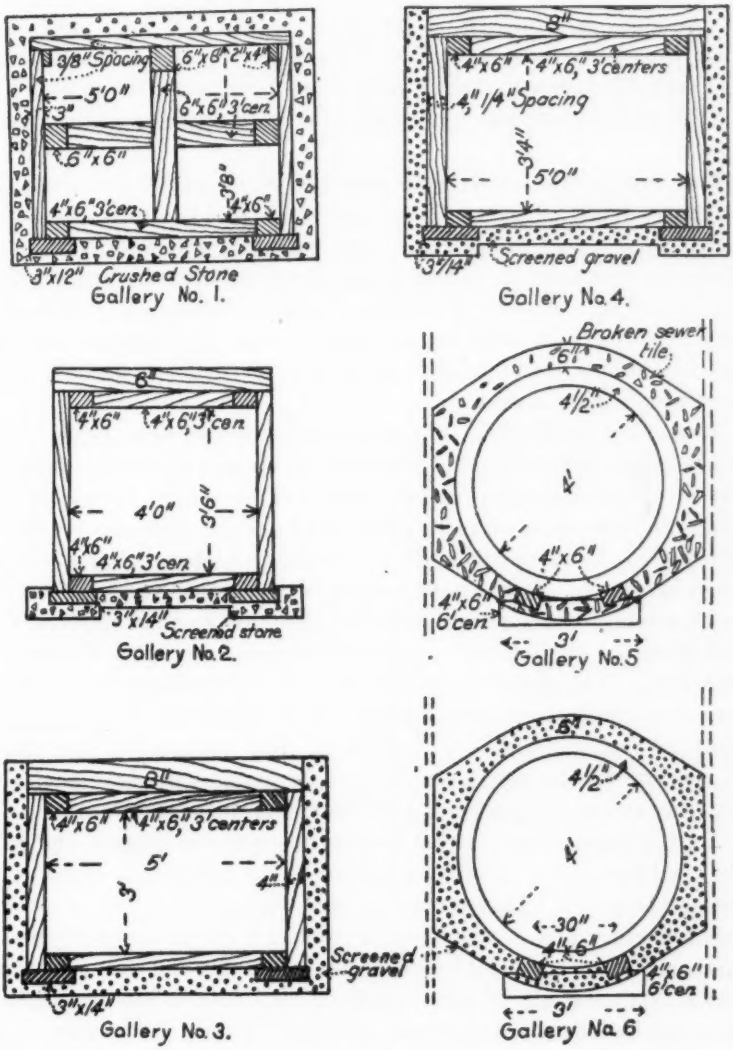


FIG. 2. CROSS-SECTIONS OF THE DES MOINES INFILTRATION GALLERIES

The top was made solid, 8 inches in thickness, and like the other two galleries, the bottom was left open. Screened gravel was placed on the sides and bottom of the gallery. For 150 feet, under the river, the gallery is protected by a 4-inch concrete slab. A low brush and rock-fill dam was thrown across the river below the galleries in the fall of this year which increased the head on the galleries about 2 feet.

Five 8-inch drive wells were constructed about 800 feet from the gallery in 1899. These wells were about 20 feet in depth, extending nearly to the clay subsoil, and were equipped with 8-foot strainers. Pumping was done by means of an electrically driven pump which discharged into the end of the No. 3 gallery, through a 16-inch cast iron pipe line. In 1900 it was decided that the operation of this equipment was detrimental to the flow in the galleries and the wells were accordingly abandoned.

It was not until 1904, that additional galleries were built. The No. 4 gallery was started in 1902 but floods and high water delayed the actual construction for two years. This gallery forms the first link in the present main gallery line and was built of similar construction to No. 3 gallery although it is 4 inches higher, being 4 feet by 5 feet in section. It was built in open cut at a depth varying from 10 to 30 feet, and extends from a point on the north bank of the river 600 feet from the suction well across the stream for a total distance of 1000 feet. The end of the gallery is connected to the suction well by means of a 36-inch cast iron siphon. A 20-inch cross connection was built between galleries Nos. 3 and 4, in order to equalize their flow. It is of interest to note that this gallery extends at right angles to the river and at its upper end is 400 feet from the nearest bank.

During times of low water it became necessary to irrigate and rake the sand bars along the river adjacent to the galleries in order to increase the yield. This procedure was expensive and more or less unsatisfactory and it was decided to extend the gallery system still further. After a careful investigation of the ground water contours and a further study of the water-bearing strata it was determined that over two-thirds of the water collected by the galleries came from the river and that the rate of this infiltration approximated 220,000 gallons per acre of river bed per day. It was accordingly concluded that extensions made parallel to the river would develop the greatest delivery.

Work was started on the No. 5 gallery in 1908. This gallery extends in a southwesterly direction from the end of gallery No. 4, a distance of 3325 feet, and consists of a series of concrete rings 4 feet in diameter, figure 3, laid on a timber cradle surrounded by 6 inches of crushed sewer tile. Each ring is 2 feet long and $4\frac{1}{2}$ inches thick, made of reinforced concrete, and has small lugs cast on one end $\frac{1}{4}$ inch high which serve as spacers between the adjacent rings. The excavation ranged from 20 to 27 feet in depth, and due to the intensely water-bearing character of the material solid sheeting had to be resorted to. Three pumping plants were used during the work, as it was necessary to handle water at rates varying from 4,000,000 to 12,000,000 gallons per day. Manholes were built at points where the direction of the gallery changed. This gallery is divided into two sections connected by 36 feet of 36-inch cast iron pipe and a gate valve. Cast iron pipe and valves were also placed at the beginning and end of the gallery. All three valves are located in valve chambers marked "V. C." in figure 1, made of brick with concrete bottoms. The work on this section of gallery was completed in 1910.

In order to dispense with the irrigation and raking of the sand bars during periods of low water, an emergency filter was built simultaneous with the construction of the No. 5 gallery. This filter consists of an earthern reservoir immediately above the gallery, divided into two sections by a street crossing. The filters are 30 feet wide at the bottom with side slopes of 1 : 1 and a total length of 850 feet, and are connected by a 24-inch vitrified tile. Water was originally admitted to them by gravity from the river through a 20-inch cast iron pipe. The bottom is at elevation 100 and the tops of the banks are at elevation 120. Without the emergency filter this gallery produced about 2,000,000 gallons per day and it was thought that there would be no further extensions needed for some time as the average daily consumption of the city was about 5,500,000 gallons per day. The demand for water, however, became greater than was anticipated, as the consumption increased over 50 per cent between 1907 and 1913, at which time it became apparent that the galleries would have to be again extended and accordingly work was started on No. 6 gallery in the fall of 1914.

The No. 6 gallery begins at the end of No. 5 gallery and parallels the river for a distance of 3500 feet. It is identical in construction with the latter gallery and is likewise divided into two sections by a short stretch of 36-inch cast iron pipe and a valve. The excavation

FIG. 3. YARD WHERE 4-FOOT REINFORCED CONCRETE RINGS WERE MADE

ranged from 18 to 20 feet in depth and was done by two locomotive cranes operating on standard gauge track on either side of the excavation. Steel sheet piling was used for lining the trenches and was driven by steam hammers supported by the cranes, or by special towers, figure 4. Water was pumped from the ditch at rates varying from 2,000,000 to 8,000,000 gallons per day. This gallery was completed and put into operation early in 1917 and completed the extensions up to the present time.

Owing to the lowering of the river level about 2 feet by sand dredging operations and the inadvisability of raising the brush and rock fill dam previously mentioned to a sufficient height to overcome this loss in head, it became necessary in 1916 to install a motor-driven low-lift centrifugal pump of 5,000,000 gallons daily capacity to furnish water to the emergency filters during periods of drouth. This plant was replaced the first of this year by a permanent low-lift pumping station located at the extreme end of No. 6 gallery. The station contains two motor-driven centrifugal pumps, each of 5,000,000 gallons daily capacity, which take their water from the river and discharge it into a series of ditches and pools extending along the land side of the gallery as far as the emergency filters. It has been demonstrated that this method of irrigation furnished water of equal quality to that filtered from the river and that it filters at the rate of about 1,000,000 gallons daily per acre flooded. At present only one pump is operated and then during only low-water stages of the river, although the average daily consumption has grown to over 8,000,000 gallons daily and a maximum rate of 17,000,000 gallons was reached last August for a short time.

In the normal operation of the galleries the pumping engines at the pumping station lower the water level of the suction well by their demand and this unstable condition of the ground water level thus created causes a draft on the gallery conduits which in turn is replenished by infiltration from the adjacent water-bearing area. The ground water then flows from either side towards the gallery; the greatest amount, however, coming from the river side. During periods of high pumpage the ground-water level immediately adjacent to the river has been drawn to a foot below the level of the water in the river. This heavy draft does not increase the yield from the river as much as might be expected, as it is limited by the permeability of the bed of the stream.

FIG. 4. VIEW OF WORK ON THE TRENCH FOR GALLERY NO. 6

In conclusion it is of interest to note the bacterial results of the operation of this natural filter plant. A chemist and two assistants are regularly employed to observe the character and quality of the water, making daily analyses of water from the river, suction well, and tap. During last year the average daily bacterial count of the river water, with samples incubated at 20°C. was 19,047 per cubic centimeter while that of the water in the suction well, as filtered through the sands, was 1061, showing a reduction of 94.5 per cent. The water is further treated with chlorine gas applied by an automatically operated machine which reduced the average daily count for last year to 47.5 or a total reduction of 97.5 per cent. It might be added that this average count at the tap is about double the normal actual count per day, the increase being due to a few high counts caused by abnormal fluctuations in the river.

THE ANTWERP WATER WORKS DURING THE WAR PERIOD[1]

I have had a double duty to perform during the recent years. It was first my duty to act as your manager; and secondly, I have had the other duty to obey the Germans. During these years of troubles, suffering, war and death, our company has not prospered. Difficulties have gained the better of us, and absorbed a great deal of our activity and profits. You will, however, make due allowance for the fact that it could not be otherwise, and that it would have deserved blame to have acted to the contrary and to prosper on the common adversity.

All our acts, consequently, during the time have been guided by one principle, to save the life of the company, to prevent its downfall under the blows of a criminal attempt, to make a stand without relenting to a tenacious foe. You may easily imagine we were not in a bed of roses, and that it was continuous vexation. It may be well to enter into some details, however. They are known to the directors but not to the shareholders. Some communication was maintained with the London office, but, for obvious reasons, nothing could be made public. Those communications were through Mr. Kemna, who remained in Holland for the purpose. Various ways had to be tried; and, as an instance, I may say now that a captain of a tugboat was very useful to us. First of all we were put under what was called "Zwangverwaltung." Literally this somewhat rough word means "managing by violence," a very proper expression.

At my first meeting with the German controller, a "Hauptmann," he looked very solemn and asked me to call into my office all members of the staff who had the power of signing the company's name. When he heard I was the only man he seemed disappointed; but he wanted an audience, and all the heads of the departments were summoned and he delivered a speech about as follows: "Be kind enough to remain on duty, all of you. We do not want any better,

[1] A statement made at the annual meeting of the Antwerp Waterworks Company in London, England, on May 12, 1919, by its resident manager. Mr. Van der Taelen.

we are so good-natured, but do not forget you are under military law. If you are unwilling you will be put in prison or sent to Germany. For the remainder, whatever money you collect belongs to us. Get as much cash as possible, and cut off without mercy customers who do not pay."

Well, we have undoubtedly insisted upon disconnecting the usual insolvent customers; and the Germans, taking advantage of the situation, for a number of German residents had re-entered Antwerp in a state of exaltation easy to picture, found fault with the collectors of an English company. But, to the others, to those whom we knew to be trusty persons, to the town of Antwerp, the suburbs and so on, we said: "Do not pay. In any case we have not too much money to give to the Germans." So it came about that at the end of the period of sequestration, which lasted fully two years, and after one year of liquidation, sundry creditors, and among them the town and suburbs, owed to the company a rather important amount of money. The system was altered at that time. By way of reprisals against the acts of you English people who have, as you well know, "set the example of all exactions," our works were put into liquidation. Some printed circulars were sent to Germany at our expense. Some "Herr Doktors" turned up, took measurements of our offices, paid a visit to Waelhem and Luythagen, tried to find fault with the installations in order to lower the price, and finally the liquidator informed us on October 3, 1917, that the concern was sold. As you will be able to ascertain, we have till this very day, for three full years, applied our dilatory politics, which may be summed up in this way: Sometimes say "Yes," sometimes say "No," but always do "No." But then, the delegate of the new owners "in partibus" resorted to threatenings, which were more in accordance with their peculiar mentality. "What was yours," he said, in fact, "we have taken; consequently it is ours. Your rights have become our rights, and you have not anything to say here. However, as all this will be definitive, until after the war is over, we are willing to keep you so as to make good all our irregularities. But we want absolute obedience, otherwise we dismiss you."

We gave to this the natural and expected answer: "All that belongs to our company remains its property. I naturally am here on the spot to stand up for its rights, and if you state officially that the transfer has been effected, I will protest officially and stand

up most positively for those rights which were conceded to us only. Neither the city of Antwerp nor myself will ever consent to retract anything whatever." The natural result followed. The usurper and I parted rather coolly. We were not made to agree. And it is a very happy circumstance that on this occasion the town acted in a fair and patriotic way, corroborating my views and not recognizing the transfer of the concern. The town then brought the question before the court, which meant much delay, but happily this time it was soon settled, on November 11, 1918, by the Allied armies acting as judges. Next day I paid a visit to the delegates of the Germany company. They seemed rather crest-fallen and two days later missed an appointment they had made. They had taken the Berlin express via Holland and £1000.

The working results are not quite so bad as could be expected. The enemy has undoubtedly taken much from us, but I am sure, as you must be convinced, that this money will be given back. The tenacity and courage of those who saved us are a sufficient guaranty. At present it will be necessary to do useful work, and although we are a bit older our situation is still hopeful. During this troubled period we have not lost all our time. The contracts with the five most prosperous suburbs have been confirmed and lately we have been able to agree with two other communes. We may consequently hope to make up a part of the time lost. Meanwhile we are able to state now that the confidence we put in our fellow-citizens' honesty was justified. Up to May 1, 1919, 281,471 francs have been paid on the arrears, without difficulty; and these amounts are now making up a very good reserve, which is more useful here than in Germany. The situation of our ordinary business is also improving; and although it is rather difficult to ascertain when we shall be able to reach the pre-war receipts again, we notice already a good increase. Closed houses were reduced by 1803 on May 1, 1919.

The receipts during the first quarter of 1919 were 656,056 francs against 482,388 francs in the first quarter of 1918 and 749,650 francs in the first quarter of 1914. Big trade meters, for factory supplies, do not yet give the expected quantities. The shipping supply has greatly improved but more business can still be done there.

All this seems to indicate that notwitstanding still very unfavorable circumstances the vitality of our company has greatly improved,

and for the first time since many years I may express sincerely the opinion that the most troublesome times are over. In short, in our own sphere we hampered the enemy as much as we could, not by actual warfare but by striking at another weak place, the pocket. All the money saved from his grasp was so much less power to him and a profit to the legitimate owners.

Addendum. In addition to these remarks it is possible to add two other statements concerning the Antwerp water works during the war period. The former manager, Ad. Kemna, well known to many American water works engineers, made a report to the Belgium military authorities on methods of protecting the water supply of the city in case of siege. He suggested using the river water at the dry docks. Early in September, 1914, he called attention to this recommendation and measures were taken to carry the plan into effect. The river water was first treated with alum and clarified and then dosed with hypochlorite, after the enemy took possession of the source of supply at Waelhem.

The chairman of the company, George Evans, reported at the annual meeting that there was some damage done to the pumping station at Waelhem by artillery fire and that the uncompleted pre-filters at Notmeir were also damaged. A claim has been made against Germany for all damages done to the plant and for the money looted from its offices. In speaking of this claim the chairman made the following statement:

> Whatever sum we may receive as compensation for the past losses, we cannot hope to be put back into our previous happy position. Even when we reach once more our pre-war revenue from sales of water, and it looks as though this result will be attained more rapidly than could have been expected, the amount of net revenue available for remittance to London must be seriously reduced. In the first place, salaries and labor charges are much higher, at least 50 per cent at the present time, with a tendency to increase, and an almost certain reduction in the working hours for some classes. This will mean at least £8000 a year. Coal is very dear and very bad; the pumping cost per cubic meter has increased from 0.028 to 0.07 franc. I hope that the price of coal may fall to some extent before long; and no doubt as soon as the world supply increases the quality will improve, but for the next year or two I think we must reckon on an additional cost on this account of at least £5000 a year.

STANDARDS OF PURITY FOR WATER USED IN RAILROAD COACHES[1]

By Zelma Zentmire

Standards of purity of water depend to a great extent upon methods of bacteriological analysis. Bacteriologists are constantly attempting to improve the methods in use, more especially procedures for the detection of sewage organisms. The water-borne diseases most dreaded in America are typhoid fever and dysentery. The causative organisms are very difficult to recognize in water, hence search is made for the more easily detected colon group always present in fecal material. Organisms of this group produce gas and acid in suitable culture media.

The methods approved by the Treasury Department, United States Public Health Service, are in many respects like those adopted by the American Public Health Association. Both use 1 per cent lactose in broth and in lactose agar. The reaction is adjusted by titration, and lactose is added before sterilization. The litmus lactose agar contains 1.2 per cent agar. The test for gas formation is made by planting lactose broth tubes with definite amounts of water and by fishing acid colonies from a plate to a tube of broth. The test for acid production consists in inoculating plates of either litmus lactose agar or of Endo's medium, with material from a broth tube which shows the presence of gas formers. According to the methods of the American Public Health Association, lactose broth tubes showing at least 10 per cent of gas after twenty-four hours incubation should be tested immediately for acid formation; otherwise, continue the incubation for an additional twenty-four hours, when gas production in any amount requires a test for acid formation. The Public Health Service requires that only tubes showing more than 5 per cent of gas after forty-eight hours incubation be tested for acid producers. The aim of this paper is to review briefly some of the more recent experimental work bearing on the detection of sewage organisms. The discussion falls naturally into six divisions.

[1] Read before the Iowa Section, April 16, 1919.

1. Recognition of the colon group. Meyer[2] advocates the use of litmus lactose agar containing 3 per cent of agar. He found that this concentration of agar inhibited the development of organisms outside the colon group. This medium compared favorably with the standard Endo medium. Hasseltine[3] finds that an Endo containing five times as much indicator as the standard Endo gives many more typical colonies, and restricts other bacteria to a greater extent. Ayrs and Rupp[4] prevent the development of the majority of other bacteria by the use of a modified Endo of such simple ingredients that practically only members of the colon group thrive on it. Kahn[5] finds the standard Endo satisfactory if used in a test tube. From a lactose broth culture a smear is made on the surface of the Endo slant. A stab culture made by inserting the wire to the butt of the tube shows reddening of the medium and gas bubbles if the colon group is present. The advantage lies in the saving of time and material due to the production of typical colonies on the slant and the simultaneous development of gas and acid in the butt of the tube. Kahn[6] in his work in the southeastern area of the United States found that this medium prevented the development of gas and acid formers outside of the colon group. Hall and Ellefson[7] use the dye gentian violet in lactose broth and in litmus lactose agar to inhibit to a very large extent all organisms except those of the colon group. Much time and material are saved by preventing the formation of gas by many organisms which are of no sanitary significance, yet are frequently present in water samples.

2. Effect of sterilization upon lactose in culture media. Lactose is used in the medium for detection of gas formers because it is fermented by the members of the colon group, though not by many other bacteria of little sanitary significance. Under certain conditions it can be broken down into two simple sugars, galactose and dextrose. Dextrose is fermented by numerous organisms, hence is undesirable in a medium for the detection of the colon group.

The most common method for the sterilization of a medium is to subject it to the action of steam under conditions of increased tem-

[2] Meyer, 1917, *Jour. of Bacteriology*, ii, 237.
[3] Hasseltine, 1917, *U. S. P. H. S., Reports*, xxxii, no. 45.
[4] Ayers and Rupp, 1918, *Jour. of Bacteriology*, iii, 433.
[5] Kahn, 1918, *Jour. of Bacteriology*, lii, 555.
[6] Kahn, 1918, *Jour. of Bacteriology* iii, 561.
[7] Hall and Ellefson, 1918, *Jour. of Bacteriology*, iii, 329.

perature and pressure, the autoclave method. Another method is to heat the medium in an Arnold sterilizer, which subjects it to the action of steam without increased pressure. Hasseltine[3] finds that sterilization in the Arnold breaks down lactose to a smaller extent than does autoclaving; Mudge[8] obtained results which indicate that the opposite is the case. He advises sterilization of sugar broth by filtration through unglazed porcelain. Levine[9] adds to melted solid media previously sterilized in the autoclave, either powdered lactose or lactose solution sterilized by heat.

3. Reaction of media. It is customary to measure the reaction of media by determining the titratable acidity before sterilization. Mudge[8] and Norton[9] report that sterilization of sugar medium by heat produces acid except where the medium is already distinctly acid. It has been demonstrated that the hydrogen ion concentration is a true measure of the reaction. The hydrogen ion concentration can be accurately determined electrometrically, but for routine work a simple colorimetric method is sufficiently accurate. Clark and Lubs[10] advocate a colorimetric procedure for routine work. Two modifications to simplify the method have been proposed.[11, 12]

4. Time required to complete a test. For obvious reasons the length of time required to determine the quality of a water is of considerable importance. Usually from forty-eight to ninety-six hours are required to prove the presence or absence of the colon group. Hall and Ellefson[7] conclude that neither the time of the appearance of gas nor its quantity gives a clue to the nature of the gas former, and that one is justified in waiting at least four days before saying gas formers are absent. Others[13] also find that the amount of gas produced is of no significance. Burling and Levine[14] find a 0.5 per cent concentration of lactose in lactose broth most satisfactory, because as the concentration of the sugar increases the longevity of the bacteria decreases. They determined acid production by gas formers as quickly as possible, preferably in from twelve to twenty-four hours

[8] Mudge, 1917, *Jour. of Bacteriology*, ii, 403.

[9] Levine, (a) 1918, *Jour. of Infectious Diseases*, xxiii, 43; (b) 1918, *American Jour. of Public Health*, viii, 3.

[10] Clark and Lubs, 1917, *Jour. of Bacteriology*, ii, 1–34, 109–136, 191–236.

[11] Barnett and Chapman, 1918, *Jour. American Medical Association*, lxx, 1062.

[12] Norton, 1919, *Amer. Jour. of Public Health*, ix, 190.

[13] Browne and Ackman, 1917, *Jour. of Bacteriology*, ii, 249.

[14] Burling and Levine, 1918, *Amer. Jour. Public Health*, viii, 306.

after inoculation of the broth. Bronfenbrenner and Davis[15] report that more than 1 per cent lactose may greatly hasten the production of gas when acid colonies are fished from a plate. In this case, however, gas formers have already been shown to be acid producers, hence there is no object in reducing the sugar concentration to prevent death of the organisms. Kahn[5] makes inoculations into his Endo tubes after about 15 hours incubation in lactose broth, even though there is no sign of gas production. In the presence of the colon group, continued incubation of the broth usually shows gas formation simultaneously with the production of typical colonies on the Endo slant and gas and acid production in the butt. Hence he completes the test in a comparatively short time.

5. Separation of the colon group into organisms of different sanitary significance. It is now accepted as a fact that the colon group includes bacteria of widely different sanitary significance. The colon bacilli are found chiefly in the feces of man and warm blooded animals, and Bacillus aerogenes chiefly on grains and in cropped soils. Levine[9] has modified two media so that it is possible to distinguish between colonies of B. coli and B. aerogenes on a plate inoculated with material from a lactose broth culture.

6. Significance of gas formers which do not show acid production. When gas formers are present in a water sample and the analyst is unsuccessful in demonstrating that they are acid formers, it has been suggested that one or more of the following conditions may exist:

1. Organisms which produce gas under anaerobic conditions, but no acid under aerobic conditions, are present.[7, 16]
2. Members of the group have died in the enrichment culture.[14]
3. Proteolytic organisms may liberate enough alkali to neutralize any acid produced.[7]
4. It may be possible that so-called "attenuated" organisms of the colon group have partially or temporarily lost their property of fermenting lactose under aerobic conditions.[7]

A study of the data secured during the past eight months in the examination of water samples from all parts of Iowa may be of interest in the light of the above discussion. There have been considered here only samples from actual drinking supplies, i.e., samples which were not grossly polluted. The data recorded were secured

[15] Bronfenbrenner and Davis, 1918, *Jour. Med. Research*, xxxix, 33.
[16] Creel, 1914, *U. S. P. H. S., Hygienic Lab. Bull. No.* **100**, 43.

from 211 samples showing gas formers and analyzed according to the 1917 Standard Methods of the American Public Health Association. Nearly all were ground waters, the majority of which were untreated. Ninety-six samples analyzed according to the method of the American Public Health Service contained gas formers. These samples were practically all treated surface waters. The test for acid production was made on litmus lactose agar plates.

TABLE 1

Relation of acid production to time of appearance of gas and quantity of gas

	TIME OF APPEARANCE OF GAS				GAS UNDER 10 PER CENT			
	24 hours		48 hours		24 hours		48 hours	
	10 cc.	1 cc.	10 cc.	1 cc.	10 cc.	1 cc.	10 cc.	1 cc.
A. P. H. A. method:								
Number of tubes gas-formers.....	47	74	77	57				
Number of tubes acid-formers.....	35	56	8	17	10	8	0	4
Percentage of tubes acid-formers...	74	76	10	30	21	11	0	4
					GAS UNDER 6 PER CENT			
U. S. P. H. S. method:								
Number of tubes gas-formers.....	9	0	205	4				
Number of tubes acid-formers.....	3	0	50	2	3	0	8	0
Percentage of tubes acid-formers...	33	0	24	50	33	0	4	0

Inspection of the table indicates that in the first class of samples acid formers were present in three-fourths of the tubes showing gas formers at the end of twenty-four hours incubation, while a much smaller percentage of gas formers were acid formers if there was no gas at twenty-four hours. A tenth to a fifth of the acid formers showed less than 10 per cent gas at twenty-four hours. Less than 10 per cent gas in forty-eight hours rarely indicated acid formers.

In the second class of samples, gas seldom appeared with twenty-four hours incubation. If absent at twenty-four hours but present at forty-eight hours, only one-fourth of such tubes contained acid formers. Four per cent of the acid formers were gas formers with less than 6 per cent gas at the end of forty-eight hours.

It is obvious that the recognition of bacteria indicative of sewage contamination is dependent upon a great variety of factors. Some of these factors are well known and easily controlled; the importance

of others is not as yet definitely determined, and still others are rather difficult to control by methods known at present. A great deal of work is still necessary before we have a bacteriological procedure for the recognition of sewage pollution of water which may be regarded as a standard method on which complete dependence may be placed.

THE RELATION OF THE CHEMICAL INDUSTRY OF NIAGARA FALLS TO THE WATER WORKS [1]

By John A. Kienle

As a prelude, and in order to show the relation existing between the electrochemical industry at Niagara Falls and the water works, the author has secured the following general statistics regarding the development of electric power at Niagara Falls by water from the Niagara River.

According to a recent estimate, the total potential power at Niagara Falls is 6,000,000 horse power. In 1916, from a total of 212,000 cubic feet of water per second, somewhat less than 56,000 cubic feet per second, or about 26 per cent, were diverted for electrometallurgical industries and municipal purposes. The former consumed about 80 per cent of the total; that is, about 44,600 cubic feet, which generated 575,000 horse power.

A treaty between the United States and Great Britain authorizes Canada to divert for power purposes 36,000 cubic feet per second, and the United States 20,000 cubic feet per second. This unequal diversion was partly caused by the desire of the representatives of the United States to treat the approved diversion problem entirely from the standpoint of scenic conditions, and partly by the fact that part of the power from the Canadian plants was transmitted after development to the American side; also, possibly, by the fact that the city of Chicago was diverting water through its drainage canal upon which a small power development was located at Lockport, Ill. The available head at Lockport, Ill., is only about 30 feet, so that any water diverted at Chicago for power development represents an economic crime, for the reason that if this same water was diverted at Niagara Falls, it would produce over eight times as much power, besides any use of it that might be made in the future possible development in the St. Lawrence River.

Furthermore, only 7000 cubic feet per second are being used at present in the Chicago Drainage Canal, which means that 3000 cubic feet are not used, which, if allowed to be utilized to generate

[1] Read before the Buffalo Convention, June 11, 1919.

power at Niagara Falls would make available an additional 60,000 horse power. This would be equivalent to a saving of 394,000 tons of coal per year.

Power development at Niagara Falls. Until 1917, of the 20,000 cubic feet per second allotted to the American side only 15,600 cubic feet were used, as allowed by the Burton bill, but since then virtually all is used, which gives as the output for the companies on the American side an approximate 278,000 electrical horse power. There is being installed on the American side equipment to eventually increase this output to approximately 400,000 electrical horse power, and, after that, by utilizing the head between the falls and the lake level and utilizing the same water, an additional 200,000 electrical horse power may be developed. The total drop from the Upper River to the level of Lake Ontario is about 300 feet, made up as follows: From the Upper River to the crest of the American Falls, 50 feet; the height of the Falls, 160 feet; and from the bottom of the Falls to the level of Lake Ontario, 90 feet.

Until recently Canada has been generating 360,000 electrical horse power, of which 125,000 electrical horse power were sold to the United States, so this country was consuming a total of 375,000 electrical horse power. Under construction now are plants which will bring the total for Canada up to approximately 700,000 electrical horse power.

According to the opinion of eminent engineers, at least half of the water in the Niagara River could be utilized without injuring the scenic effect; by installing the proper weirs and submerged dams, the recession of the Horseshoe Falls, which is now at the rate of 5 to 10 feet per year, could be obviated and the natural beauty of the Falls would be improved rather than impaired. This loss or waste of crest on the Canadian side has frequently been termed in public lectures on the subject "the suicide of the Horseshoe Falls."

The distribution of power at Niagara Falls is as follows:

	horse power
Electrometallurgical	82,500
Electrochemical (including chlorine and alkali)	44,000
Carbide, carbon and graphite products	65,400
Municipal	35,750
Miscellaneous (including paper manufacturing)	38,000
Abrasives	12,250
	278,000

Electrically made products. The number of products made at Niagara Falls is very extensive when we consider that the advent of the electro-chemical industry took place only twenty-four years ago. The first consumer of water power was the Aluminum Company of America, formerly known as The Pittsburgh Reduction Company. Its product, aluminum, enters into many industrial fields and finds ready application in the following list of products which are of essential use to the water works.

1. Automobile parts: Engine bed, crank case, transmission case, rear axle housing, running board, fans, seats, bodies, etc.
2. Electrical instruments: meter frames and meter covers.
3. Sheet metal: sheet auto bodies.
4. High tension feeder cables and bus bars.
5. Clock parts, bronze powders, pump parts, gaskets and fuses, as well as a deoxidizer of steel in the making of sound steel castings.

Another product of great importance is the one commonly known as "abrasives" which comes into the market as "alundum A" and "silicon carbide A." The trade names for the former are alundum and crystolon and these find special application wherever any material of high tensile strength or great hardness has to be ground or shaped. For instance, a manganese steel which cannot be cut by any tool, would still be a curiosity were it not for the aluminous abrasives which shape this material, so that such appurtenances as gears and burglar proof safes can be made from it. Besides grinding the above, this artificial corundum is used to grind crank and cam shafts, pistons, cylinders, forgings, castings, ball and roller bearings, all of which are to be found in any water works.

The silicon carbide abrasives, also known as carborundum and garnet products, are chiefly employed for grinding materials of low tensile strength, such as cast iron, brass, aluminum bronze, marble and granite, and wherever such a material is to be found in a water works it is certain that the abrasive has lent its aid to make the finished product. Every workshop in such an establishment always finds use for these abrasives.

Calcium carbide finds its chief use for making acetylene, which since the beginning of the oxy-acetylene welding industry has far outstripped its former use as illuminant. The latter, however, is still in great demand and many a water superintendent's night call involves the use of the carbide light. Also, as an emergency fuel, acetylene or calcium carbide plus water is of great help.

The various ferro alloys manufactured at Niagara Falls are ferro-silicon (FeSi), ferro-chromium (FeCr), ferro-tungsten (FeW), ferro-molybdenum (FeMo), and ferro-titanium (FeTi). Their greatest use is naturally in the direct war industries as shell steel, armor plates, projectiles, etc., but wherever high speed tool steel is required, one of these alloys will find its way into the manufacture of the specific material.

Ferro-silicon is used extensively as a deoxidizer for steel, from which it not only removes the oxygen but also any blow holes, both of which tend to weaken any casting, whether steel or cast iron. Approximately three-quarters of all steel made in the United States today contains ferro-silicon as one of its important ingredients.

Ferro-chromium makes a very hard steel which is used for ball bearings, dies, crushing jaws and tools. It needs no explanation how each of these finds its application in such an establishment as a water works.

Tungsten, vanadium, and molybdenum alloys are especially adapted for the manufacture of high speed tool steel, while the ferro-titanium is of great importance to steel and cast iron castings, bearings for pumps, and steam engines.

Speaking of alloys there is also manufactured at Niagara copper-calcium alloy which is used for deoxidizing copper, brass and bronze. The injurious effect of oxygen upon the electrical conductivity of copper is too well known to speak of it here.

Some of the products which find a more limited use in the water works are "refractories," such as crucibles, filtering devices, and extraction thimbles, made from alundum and carborundum, which enter into a laboratory equipment. Combination bricks for building purposes are also made from it.

Silicon, which is used in such alloys as silicon bronze, although not as good a conductor as copper, because of its greater strength is used for telephone and overhead electric wires.

Magnesium enters into the light weight casting and alloys industries, brasses and bronzes, and in the powder form is used as a pigment for paint and flash light powders. Of much greater importance is graphite, an excellent lubricant. Every battery contains it. Brushes and resistances for electrical devices use large quantities, and paint, lead pencils, hard rubber and pipe joint compounds are all outlets for this useful Niagara Falls product. Allied to the above is the carbon electrode industry which serves to supply the arc and searchlight and battery carbons.

It is to be borne in mind that here only those uses are enumerated as find application in some way, directly or indirectly, in a water works. To do full justice to each of these products would require too much time, for the field is broad and expanding continually.

Under the general heading of chemicals, there loom liquid chlorine and its related products, such as bleaching powder, chlorates and perchlorates; chlorinated organic compounds, as carbon tetrachloride, mono and dichlorbenzol; also, hydrochloric acid and sulphur chloride.

Chlorate of potassium is used for making matches; is contained in blasting powder, paints and fireworks (signal lights); and is also employed for welding.

Carbon tetrachloride is the well known main constituent of the pyrene extinguisher; and appears in the water works as an indicator in hydraulic instruments, notably the pitometer and chlorinator.

Sulphur chloride is used for vulcanizing rubber used as insulators, etc.

Other chemicals, like caustic soda and potash, which are manufactured along with chlorine are very useful. Caustic potash is used for special soaps and lubricants, but on account of its greater cost, it is not as freely applied as caustic soda, which is an essential material for soap and paper making, greases, lubricants, and oil refining. It is also a much used laboratory reagent.

The various leather belts used around the water works plant have, as a rule, been treated in the tanning process with such miscellaneous chemicals as bichromates, chromalum and sulphate, all manufactured at Niagara Falls. Ferro-chrom, phosphorus, sodium metal, hydrochloric acid, etc., all Niagara products, are extensively used in laboratories. Phosphorus particularly enters into the manufacture of phosphor bronze, an alloy, extensively used throughout the mechanical equipment of the water works, especially pumps, engines, meters, etc.

Formaldehyde and para-formaldehyde are excellent disinfectants and are also employed in the Baekelite process for making acid-proof varnishes and lacquers.

All glass used around the water works plant, in most cases, has embodied in its manufacture, sodium sulphate, which is a Niagara product.

MANUFACTURE OF CHLORINE AND BLEACHING POWDER

Quite naturally the major interest of the water works in the electrochemical industry at Niagara Falls centers in the two products, liquid chlorine and bleaching powder, manufactured by the electrolytic method. Therefore, a brief description of the two processes of manufacture will no doubt be of interest. For two main reasons the making of bleaching powder antedates the manufacture of liquid chlorine, first, the lack of a source of pure chlorine and second, the difficulties encountered in the liquefaction of the gas itself.

Chlorine was originally produced by the so-called chemical process, which resulted in a product of uncertain quality and strength. The development of the electrolytic method in its manufacture, which method has been the only one commercially used in this country, overcame this trouble. The difficulties of liquefaction, however, were not overcome until more recently, when refrigerating machinery and gas compression machines had been more fully developed.

Bleaching powder is a compound made from slacked lime and chlorine gas. The lime, which must be the best high calcium lime obtainable, is slacked with just the proper amount of water to make a dry compound (calcium hydroxide) known commercially as hydrated lime. To expose as large a surface of this lime as possible to the action of the chlorine, it is spread in ridges on the floor of a chamber or room, figure 1. These chambers are gas tight and are made of lead, concrete, brick, or even wood; the latter three, being less resistant to the action of the chlorine, are heavily coated with pitch. The chambers, several of which are required for a plant, are connected in series with acid-proof tile or lead pipe, so that the chlorine gas can be led into several of them in series. After the lime is spread on the floor the chlorine is turned into the chambers. The gas that is not absorbed in the first chamber is run into another chamber, and so on until the exit gases are free from chlorine.

In some cases, if a weak chlorine is being handled, the exit gases are run through a washing tower to remove the last traces. Chlorine is run into a chamber until the lime has absorbed 35 to 40 per cent. The gas remaining in the chamber is then drawn into a fresh chamber and the bleaching powder is shoveled through a chute in the floor into drums or barrels. Bleaching powder is a compound that is very sensitive to changes in temperature, and when exposed to the

air loses its chlorine strength rapidly. Even when sealed in drums decomposition occurs, especially in the hot summer months.

Liquid chlorine. While bleaching powder is very widely used and also a very necessary product, the demand for a more convenient form of chlorine is evidenced both by painstaking and costly development of the liquefying plants and the immediate success which liquid chlorine attained when introduced. Chlorine was liquefied commercially in Europe in 1889 or thereabouts. As said before,

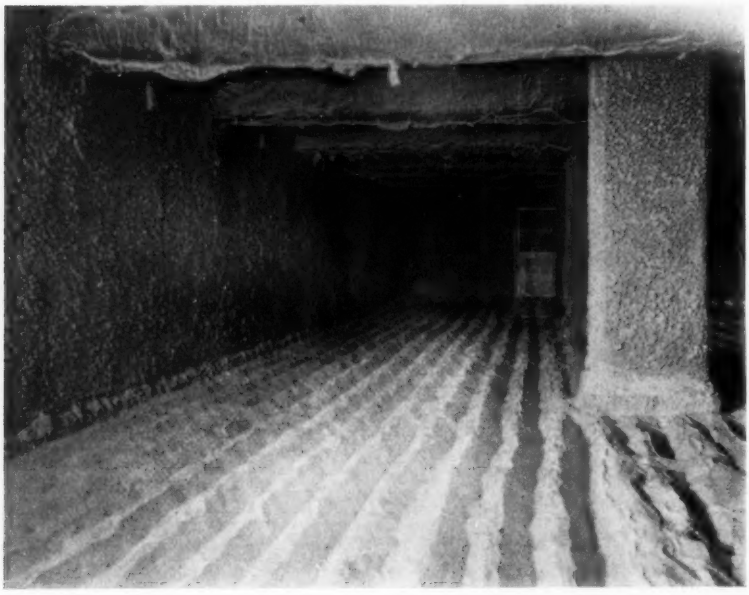


FIG. 1. INTERIOR OF A CHAMBER IN WHICH HYPOCHLORITE OF LIME IS PRODUCED

successful liquefaction of chlorine awaited a source of pure gas. This followed the introduction of the electrolytic cell, in which electric current breaks up common salt into chlorine and caustic soda, or more correctly sodium metal, which forms caustic soda and hydrogen with the water present.

The two types of cells in actual operation today are, first, the cell in which the two electrodes, cathode and anode, are separated by a porous partition or diaphragm; second, the cell in which there is

no diaphragm, but in which a mercury cathode dissolves the sodium metal as it is formed.

There are many modifications of the first type, which is generally known as the diaphragm cell. Those most widely used in this country are the Nelson, Allen-Moore, Wheeler, Townsend, Dow and Billiter. The main points of differences in these are in the disposition of the diaphragm and the anode, which is of Acheson graphite in all cases. With the exception of the Billiter cell, the

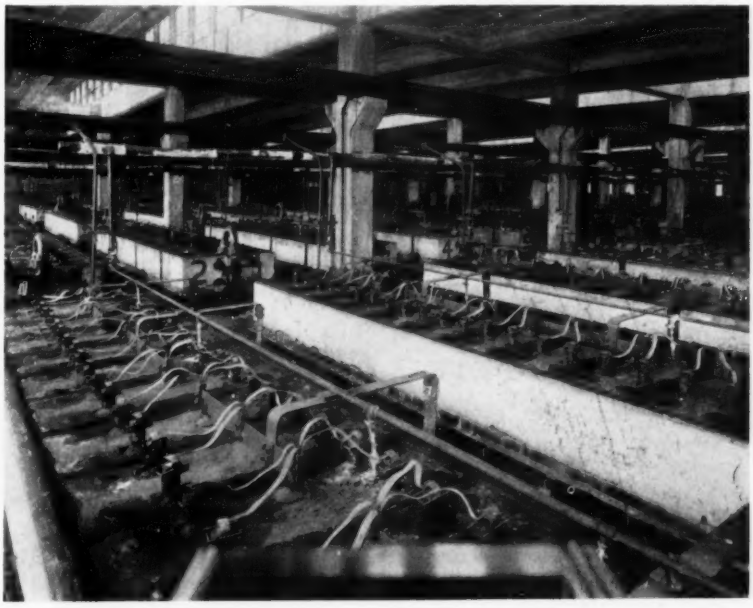


FIG. 2. ELECTROLYTIC CELLS FOR PRODUCING CHLORINE AND CAUSTIC SODA

diaphragms are vertical and made of asbestos cloth or paper, and in some cases impregnated with other materials to give uniform porosity. The Billiter cell has a horizontal diaphragm of asbestos cloth overlaid by a layer of barium sulphate and asbestos fiber, with several inches of brine above it. In this type of construction the chlorine and hydrogen cannot mix, as they are separated by a layer of brine. For the many points of differences in the above cells reference is made to the standard books on electro-chemistry, as this paper can touch only briefly on the general principles. An interior view of a large cell room is shown in figure 2.

In the second type of cell, known as the Castner cell, brine is decomposed and the chlorine gas is formed at the anode as in the other cells. At the cathode, which is a layer of mercury on the bottom of the cell the metallic sodium is dissolved by the mercury. The whole cell is rocked slightly back and forth by an eccentric cam and the solution of sodium in mercury runs into a compartment at the end of the cell where it comes in contact with water, forming caustic soda and hydrogen. As the cell tips back the mercury runs into the electrolyzing chamber to become saturated with metallic sodium again and the cycle is repeated.

The chlorine formed at the anode in all the various types of cells is much purer than that formed by the older chemical processes, and runs from 40 to 98 per cent of chlorine with small percentages of carbon dioxide, oxygen, and in some cases small amounts of hydrogen.

Pure chlorine gas can be condensed to a liquid at $-34°$C. at atmospheric pressure, or at ordinary temperatures, say 15°C., by a pressure of 6 atmospheres. With gases containing a lower percentage of chlorine the pressure must be increased or the temperature lowered, or both, to give commercial yields of liquid chlorine. However, when the liquid chlorine has been separated from the other gases present, which do not liquefy under the above condition, it follows the gas laws for 100 per cent chlorine and contains at most only minute traces of other gases.

Chlorine when dry does not attack most of the metals, but before drying must be handled in lead or stoneware pipes. Before compression chlorine gas is dried in coke or stoneware packed towers by strong sulphuric acid which absorbs the moisture but dissolves only a small amount of chlorine.

To secure the necessary pressure of from 30 to 100 pounds per square inch for liquefaction various means are used. Some of the machines are similar to air compressors, figures 3 and 4. Lubrication of such machines is the big difficulty, as chlorine attacks all oils, forming hard or gummy chlorinated compounds. For this reason sulphuric acid is largely used as a liquid compressing agent, in spite of its disadvantages. In one type of machine a U-tube is used, in one limb of which a piston works; the other limb and the lower part of the U are filled with strong sulphuric acid. As the piston rises and falls in one limb the sulphuric acid rises and falls in the other forming a liquid piston which compresses the gas. The

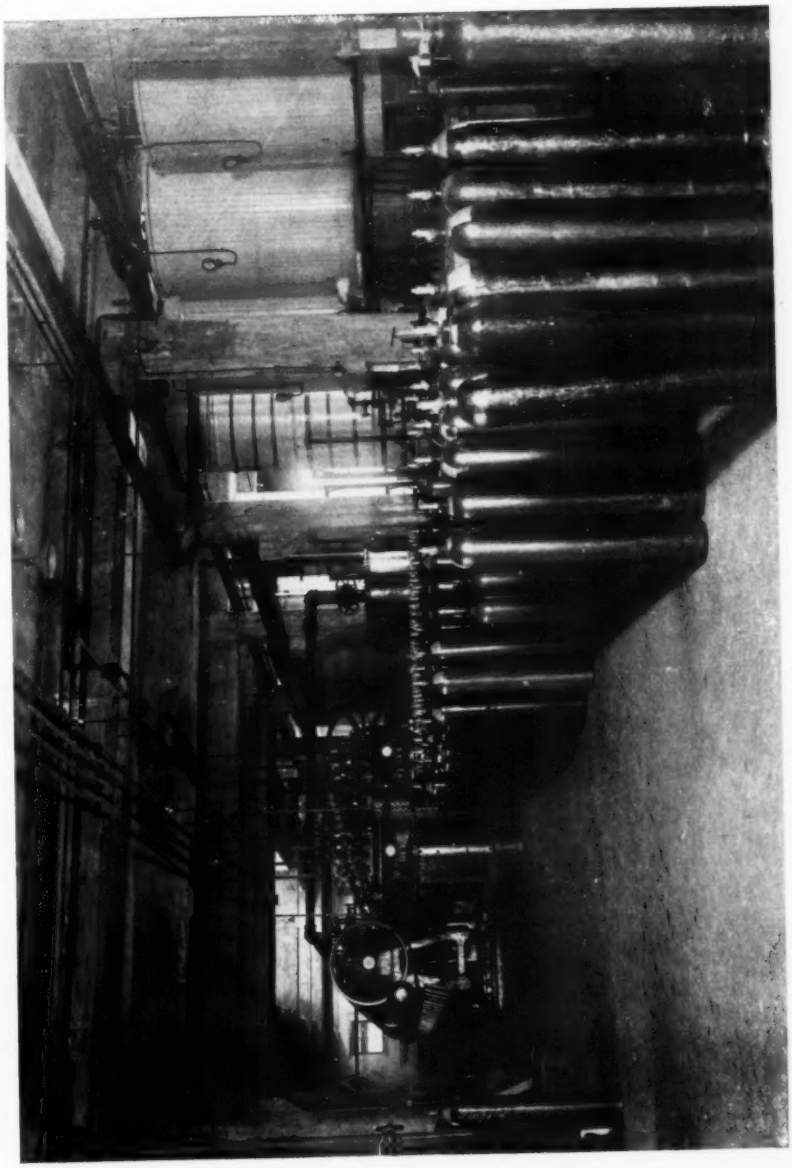


FIG. 3. VIEW OF THE COMPRESSORS IN A PLANT PRODUCING LIQUID CHLORINE

inlet and outlet valves are located in the top of the limb containing the sulphuric acid. Another type of compressor depends on the head of a falling stream of sulphuric acid to give the necessary pressure. A tower 75 to 100 feet high carries at the top an injector, through which a stream of sulphuric acid is pumped. The injector draws in chlorine gas, and as the bubbles of gas pass down the pipe to the bottom of the tower the head of sulphuric acid compresses them. At the bottom of the tower is a separating tank. The gas is taken out of a dome on the top and the sulphuric acid is drawn from the bottom and returned to the injector at the top of

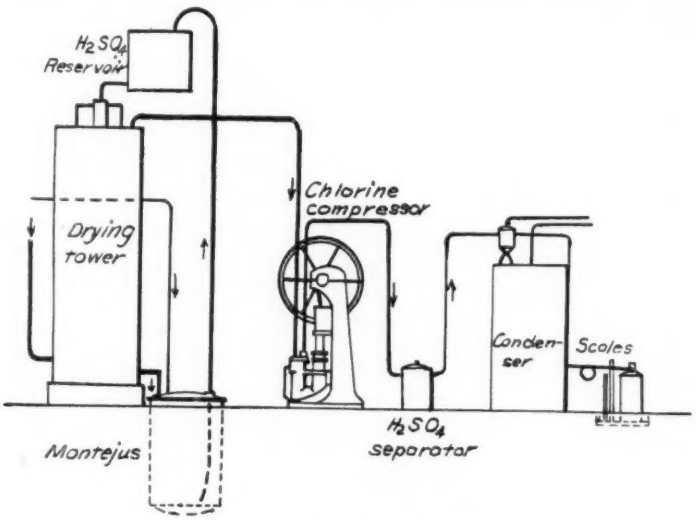


FIG. 4. SCHEME OF A CHLORINE-LIQUEFYING PLANT

the tower. This type of compressor gives a much lower pressure than the various reciprocating pumps. It is in reality an air lift turned up side down. The height of the tower upon which the pressure depends is naturally limited.

After compression, the chlorine gas is cooled by mechanical refrigerating machines, either of the ammonia or carbon dioxide type, to $-30°$ to $-70°$C. At this temperature a varying quantity of the chlorine present in the compressed gas liquefies. The liquid is drawn off into cylinders, tank cars or other containers for shipment to the consumer. The chlorine contained in the waste gases is run into the bleaching powder chambers, or used in other chlorinating processes throughout the plant.

CHLORINATION OF WATER SUPPLIES

That chlorination of public water supplies has been the most noteworthy single contribution to the art of water purification in recent years, the author believes is conceded beyond question by all sanitarians. Furthermore, the effect of this method of water treatment in reducing the typhoid mortality of the country at large is attested not only by the statistics but by the increasing demand of public health authorities for this method of protection.

So much has been written on the subject that the author hesitates to present other than the general data to show the remarkable growth of the process, and consequently the important relation that this branch of Niagara's industry bears to the water works and to the health of the country. The writer wishes to call attention to the comprehensive treatise on the chlorination of water recently published by Joseph Race, which presents in a most concise manner many of the more important data on the subject.

The majority of the members present are, no doubt, familiar with the fact that chlorination of water by the hypochlorite of lime method was first carried out successfully in the United States by George A. Johnson at the Union Stock Yards at Chicago in 1907, and was almost immediately followed by the treatment of the Jersey City supply at Boonton, also with the lawsuit which it involved and the variety of expert opinion submitted as to the efficacy of the process, with the resulting court decision in its favor. Immediately following this there was a rapid growth in the use of this method, and by the end of 1911 approximately 500 water plants had been equipped with hypochlorite installation, and close to one billion gallons of water thus sterilized.

It is interesting to note at this junction that development of this art settled at once, and apparently for all time, the much mooted controversy between sanitary engineers on the question of the suitability and ultimate efficiency of rapid and slow sand filtration as the correct means of water purification. The doubt that had previously existed as to the quality of water delivered from rapid filters was at once eliminated by the bactericidal effect of chlorination upon the effluent, and the process became a very necessary adjunct to all filter plants.

It is perhaps purely coincident that at this stage of the development of the chlorination of public water supplies there was a tem-

porary interruption in the downward trend of the country's typhoid rate, extending into the year 1912. The author is inclined to believe that the use of hypochlorite of lime as a sterilizing agent had about reached its maximum usefulness by reason of the fact that the majority of those water plants, where the proper control and supervision of hypochlorite application was possible, had by this time been equipped with hypochlorite plants. The many inherent disadvantages in the use of this chemical for sterilization of the smaller city supplies is well known and it is only necessary to cite the most recent evidence in the case of Xenia, Ohio, to substantiate the above claim.[2] Xenia had a rather severe typhoid epidemic, notwithstanding the application of hypochlorite, due solely to the failure of the attendants in charge to realize or understand that hypochlorite loses its chlorine strength rapidly in storage and that the deteriorated lime powder has no effect on the bacterial content of the water. The author unhesitatingly makes the deduction that it is extremely fortunate for the country's welfare that the use of liquid chlorine was developed at this stage of the campaign against preventable diseases.

The American Water Works Association was first advised of this newer process at the Minneapolis convention in 1912. The first to use liquid chlorine was Major Carl R. Dowall at Fort Myer, immediately followed by commercial experiments at Niagara Falls, Wilmington, Philadelphia and Brooklyn, by several investigators operating independently.

Although the increase in the use of hypochlorite was quite rapid, following its application at Boonton, the rate of growth of the liquid chlorine process was even more pronounced. From only one water plant, viz., Niagara Falls, equipped at the end of 1912, the number at the end of 1918 had jumped to a total of approximately 2500. The more populous urban districts throughout the country, particularly those states where the State Boards of Health are most active and efficient in their work, are the ones which have progressed most rapidly. No doubt this is largely due, as stated by George A. Johnson in his excellent paper,[3] "The Typhoid Toll" to the failure of the various State legislative bodies to provide suitable laws and appropriations for the health boards properly to conduct

[2] See JOURNAL, June, 1919, p. 167.
[3] See JOURNAL, June, 1916, p. 249.

educational and investigative work, and more particularly a thorough supervision of the quality of water supplied to the communities.

In 1907 the United States Census Bureau reported that the typhoid fever death rate in the registration area with a population of 41,758,000, was 30.3 per 100,000, and the estimated number of deaths within the year for the entire country was approximately 30,000, and in that year there were no chlorinated water supplies.

In 1917, the latest year for which figures are available from the United States Public Health Service, the rate had dropped to 12.3 per 100,000, with the estimated number of deaths stated at 13,000, and in this year there were at least 2000 public water supplies that were chlorinated. There were 17,000 lives saved from death by typhoid in one year, to say nothing of other water-borne diseases or the increase in vital resistance to other diseases.

Perhaps these figures will impress themselves more forcibly by the simple statement that the chlorination of water has been the major factor in saving more lives in the United States since its inception 10 years ago than were lost by the United States forces in the world war. Think for a moment just what this means expressed in vital capital; 17,000 lives at a value of $7500 each, which figure includes allowance for lost wage, medical attendance, lowered vitality, etc., in the proportionate case rate, result in a saving of over $125,000,000 annually. As the figures available represent only the mortality statistics of the so-called registration area, the estimated population of which is approximately 70,000,000 people, it is apparent, if the total population of the United States be assumed at 110,000,000, that there is left approximately 40,000,000 population for which there are no available statistics to show the death rate.

Perhaps a clearer view of the possibilities of improvement in the typhoid situation by the simple chlorination of water may be obtained by a study of the total number of public water supplies which exist in the United States. Obviously, it is difficult to get any definite figures on the exact number of these, but a careful investigation a few years ago indicated that the number of such supplies was something more than 7500. If we take the number of supplies that have been stated as being filtered or chlorinated at 2500, it is apparent that but one-third of the number of supplies has this protection. It is also clear that the balance, or two-thirds, must feed those smaller cities in the less populous districts of the

United States. If we assume the total urban population served by the above number of water supplies at 60,000,000 and the number receiving chlorinated or filtered water is, according to best estimate obtainable, 40,000,000, there is a balance of 20,000,000, the major portion of whose lives are more or less in danger by the failure of the authorities to chlorinate the water.

It is obviously not fair to take the typhoid statistics of the total registration area as a basis for computing the possible improvement that might occur if these 5000 water supplies were chlorinated, for the reason that the total statistics include the death rates occurring

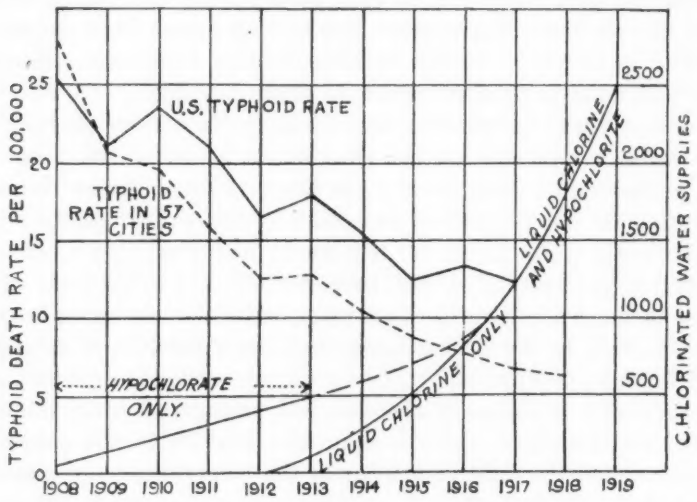


FIG. 5. RELATION OF CHLORINATED WATER SUPPLIES TO TYPHOID DEATH RATE

in the rural districts. For this reason it seems very much more logical to take the mortality rate of the urban population. In order to obtain an idea of the effect of chlorination on the urban typhoid statistics a curve showing the death rate in 57 principal cities, compiled from the statistics of the *Journal of the American Medical Association*, is shown in figure 5. From this it is seen that the average typhoid rate in these cities in 1908 was 28 per 100,000. In 1918, after 10 years of gradual improvement in the quality of water delivered to the consumer the rate dropped to 6.2 per 100,000.

Now, if we assume that the death rate in those municipalities not receiving purified water approximates even the low average

condition existing in the registration area in 1917, it becomes apparent that the annual loss of life in the 20,000,000 of urban population would represent a total number of deaths annually of not less than 2500. Reducing this to vital capital, it would represent a loss annually of $18,750,000. A corresponding investment valued at 6 per cent is $312,500,000. The cost of installing 5000 additional chlorination plants would certainly not exceed $3,000,000, or only 1 per cent of the capitalized value of the lives lost. The interest, depreciation and operation charges would not exceed $750,000. Compare this also with the annual loss in vital capital.

It has been aptly stated that the chlorination of public water supplies is the cheapest municipal insurance that can be obtained, the average annual premium amounting to not more than 40 cents per million gallons of water treated, or, for a municipality of 5000 or less, an annual expense to the municipal government of $150 per annum ($36.50 operating, and $120 depreciation at rate of 20 per cent) or a cost per capita based on the same figure of 5000 population, of 3 cents.

In the State of New York in 1908 the typhoid death rate per 100,000 was 16, while 10 years later it had fallen to 5.4 per 100,000. Approximately 1200 lives were saved in one year from death by typhoid. There are in the State 510 public water supplies, serving a population of 8,700,000 out of a total population of 10,682,000. Of the total number of water supplies, 125 are purified by filtration or chlorination or both, and the population served is approximately 7,000,000, leaving 385 supplies serving a population of 1,700,000 without water supply properly protected, or an average population of 4400 per supply, which corresponds favorably to the assumption regarding the country's average condition in the preceding part of the paper. In Pennsylvania a death rate of 32.4 in 1908 was reduced in 1918 to 10 per 100,000. Out of a total population of 8,750,000 in the State, less than 4,000,000 were receiving purified water. The total number of supplies amounted to about 1200, with less than 140 having proper protection.

Connecticut, with 104 public water supplies only 24 of which are today being treated, shows a reduction in the death rate from 18.4 in 1908 to 5.3 per 100,000 in 1918.

New Jersey, snuffing out the lives of 408 of its citizens in 1906, reduced its loss in 1918 to 162. Are not these 162 people worth an effort when it is considered that out of a total of 184 surface water

supplies (69 underground having been eliminated from the count) only 36 are chlorinated.

There have been prepared two line charts, figures 6 and 7, showing the reduction in typhoid, first, in five of the principal cities of the United States where the water supply is both filtered and chlorinated, Philadelphia, Baltimore, Pittsburgh, Cincinnati and Minneapolis; and second, five other principal cities—New York, Jersey City, Buffalo, Chicago, and Milwaukee, where the only treatment the water receives is chlorination.

The author's purpose in presenting these charts is mainly to show that so far as reduction in typhoid mortality, as related to water supply improvement, is concerned, chlorination is quite as effective as filtration. It is not, however, his intention to create the impression that chlorinaton is to be in the slightest way considered as a substitute for filtration. There are today, no doubt, many chlorinated water supplies that should be filtered. The use of chlorine does not in any way change the physical or chemical characteristics of the water. It will not rectify the water from the standpoint of appearance as it will remove neither turbidity nor other suspended matter, while its effect upon color is almost negligible. The important point, however, is its known bactericidal action and the absolute safety of the treated water for drinking purposes. The filtration of water has proven its worth so thoroughly and frequently that it needs no further evidence of its value here, its place in water treatment is vital, but just as chlorination is not a substitute for filtration, so also filtration should not be considered a substitute for chlorination. The dangerous bacteria still lurking in the filtered effluent should be destroyed by chlorine and the water rendered sterile.

Niagara Falls has contributed much to the general welfare of the country but its contribution in safe-guarding of public health through its relation with the water works stands supreme. It has available the power and facilities to do considerably more, yet what it can accomplish in the future rests with the State and municipal health authorities. Where there is a lack of appreciation by these the responsibility must logically be assumed by the water works superintendent.

In concluding the author acknowledges, with full appreciation, the courtesy and assistance extended by the staff of the Wallace & Tiernan Company and the Niagara Alkali Company in collecting many of the data entering into the preparation of this paper.

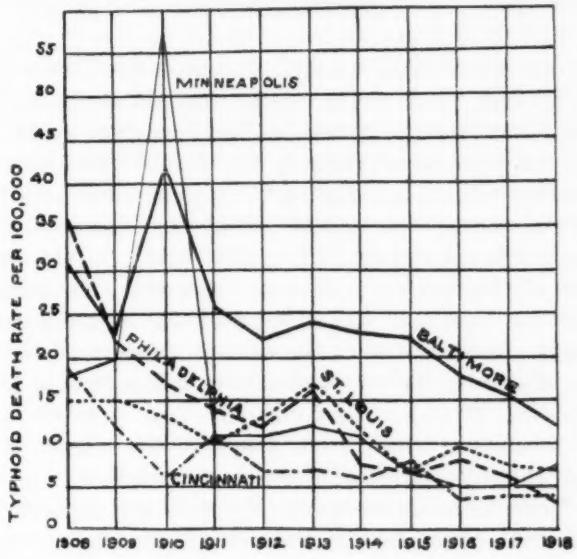


FIG. 6. TYPHOID DEATH RATES OF CITIES WITH FILTERED AND CHLORINATED WATER

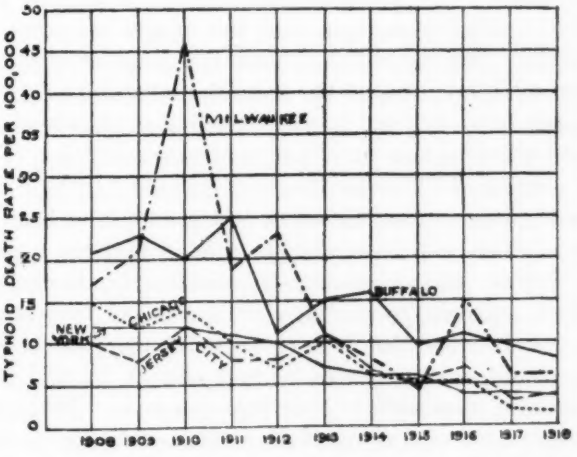


FIG. 7. TYPHOID DEATH RATES OF CITIES USING WATER TREATED ONLY WITH CHLORINE

DISCUSSION

LIEUT. COL. GEORGE A. JOHNSON: Ten years ago little was known of the advantages which would accrue from the use of chlorine in the sterilization of water. Something had been done in sterilization of sewage, but scarcely anything in the way of water sterilization. An almost unparalleled opportunity for a spectacular exhibit of the advantages of chlorination was offered at the Chicago stock-yards where a very unique water problem was presented, and the immediate advantages of this treatment became apparent. The adoption of the chlorination treatment was widespread, but its use was clandestine in many cases because of the natural aversion on the part of many city officials to the use of chemicals in any form in the treatment of water. It was at first unwisely used in many instances, yet the advantages which have followed the almost universal adoption of the chlorination of water are tremendous.

It is difficult to measure exactly the part that chlorination has performed in the reduction of water-borne disease. It is an exceedingly difficult thing to explain it plainly and convincingly, because there are so many other influences that enter into the reduction of typhoid fever. There is no question but that we must be fair-minded enough to realize that medical treatment is better now than it was ten years ago; and, too, people are more sensible in their habits. But nevertheless there is a great amount of credit to be given to chlorination in the reduction of water-borne disease.

The author is correct and fair in stating that chlorination is not a substitute for filtration; it is not, and never will be. Probably the most pernicious influence that chlorination has had has been its adoption in cases where the water first should have been filtered. Wherever a given water contains suspended matters, particles of vegetable debris, and what-not, chlorination treatment alone is liable to be dangerous, because it gives a sense of false security to the user, who believes that it is to be relied upon to the extent of 100 per cent efficiency provided he gets enough in, and gets it in consistently and constantly. Now that is not so. Bacteria, or at least bacteria of a disease-producing character, can become imbedded within the particles of suspended matter so that notwithstanding the action of the chlorine, they pass on to the mouth of the ultimate consumer and cause disease and death.

There is no question that the real ideal method of water treatment is, first, complete clarification by filtration, followed by sterili-

zation with chlorine, and that is what the American municipalities are coming to today, the speaker believes; it is at least what they should all come to. Chlorination alone is about as bad as filtration alone, indeed, it is even worse. It is preferable to depend upon a filter plant to give maximum protection than on chlorine alone; but the two together furnish, it seems to the speaker, 100 per cent protection, whereas neither one of them alone accomplishes that. There is, of course, a possibility of having waters in some cases that are free from suspended matters and can be treated freely and thoroughly with chlorine alone; but by and large, we ought to come to the practice of filtration first and chlorination second. They are worth their cost to any municipality, because they do give 100 per cent protection against water-borne disease.

M. N. BAKER.—There can be no question in the minds of any that have followed either the development of this matter or the excellent paper that has been presented, that chlorination is one of the sanitary marvels of the age. Of course, as has just been suggested, chlorination and filtration ought to go together and share the credit for all the typhoid reduction that has taken place; but either alone, and certainly the two together, have played their part in bringing about this reduction, and almost the entire part in many instances. It is not so very long ago that a typhoid death rate of 20 or over per 1000 would cast a shadow of doubt upon the purity of a water supply. It is shown now by the figures that the American Medical Association publishes in its *Journal*, to which the author referred, that there are a considerable number of cities whose typhoid death rate is well below 5, and a few that have been down to 2, or even below that; so that we are certainly making marvelous progress. Water works men have nothing upon which they can more justly congratulate themselves than this reduction in the typhoid death rate, in which they have played so important a part in the last few years.

HENRY P. BOHMANN: Perhaps the members of this Association will be interested in Milwaukee's experience in treating its water supply. The city gets its water from Lake Michigan; it is not filtered, but chlorinated. In 1910, there was a typhoid epidemic and bleach was first used at that time and the epidemic was promptly checked. Later on we changed to liquid chlorine. It was noticed from time to time that a very obnoxious taste appeared

in the water, which we of course attributed to the use of chlorine. But it was also noticeable that when the quantity of chlorine used was cut down, the taste did not immediately disappear; it took several days for this to happen. After making further investigation it was found that the taste only appeared when the wind was blowing in a certain direction. When the wind blew from the southwest it carried sewage toward the intake, and the taste became so obnoxious at such times that it was impossible to drink the water, in fact, some of the patrons of downtown restaurants refused to pay for their meals and threw the dishes on the floor.

At the last convention a member of this Association gave it as his opinion that sewage discharged from a coke plant entered their water supply and that, together with the chlorine formed compounds that produced taste. An investigation was made along that line. In the city, sewage was being discharged from a coke plant, and experiments with that sewage proved that it was possible to reproduce the exact taste in the city water supply. Experiments were also made with benzol, naphthalene, etc., and with each one of these it was possible to reproduce the identical taste observed in the water supply. Samples were taken from the different tanneries, packing-houses and intercepting sewers, to try to reproduce this taste with their sewage, and this was found not possible except with sewage of a coal-tar derivative nature. Experiments made with phenol showed that one part of phenol would impart taste to 500 million parts of water if chlorinated. There is a phenol plant doing work for the Government about 13 miles from the intake. Investigation was made there, and it was learned that about 2200 pounds of concentrated phenol was getting away from that plant daily, an amount sufficient to pollute the whole lake.

The officials of that plant claimed that they were doing Government work and the water department could not possibly interfere with them. The department enlisted the aid of the Governor, telegraphed to Washington, and persuaded specialists of repute to go over the experiments that the department had made. Fortunately the armistice was signed at about that time and that plant was closed. However, that was the only thing that saved the situation. When the department first came out and accused different companies of being the cause of the pollution of the water supply they published half-page advertisements in every daily and weekly paper in Milwaukee denying it. The speaker had the satis-

faction of having the manager of the phenol plant openly admit before the Chemical Society that they were undoubtedly the cause of the trouble, and that through the department they had learned a few things about their own business that they did not know before. Since then the plant was closed, and the coke plant has diverted into other channels its sewage which formerly reached the intake; there has been no taste since that time. The department fully demonstrated the fact that a taste like phenol or iodoform is not necessarily due to chlorine treatment. The chlorine has to be in combination with sewage of a coal tar derivative nature. It is possible by boiling water to expel the chlorine taste, but it is impossible to boil out that particular taste because it is due to a substance that has a higher boiling point than water. The subject is discussed at length in the last annual report of the department.

MAURICE R. SCHARFF: It may be interesting to compare the author's statement as to the growth of the use of the liquid chlorine treatment in America with the situation in that respect in France. Lieut.-Col. Edward Bartow, in charge of the laboratory work of the American Expeditionary Force in France, started in the Fall of 1917 in cooperation with a well-known French scientist a series of experiments on the use of liquid chlorine in Paris, and succeeded in showing to the satisfaction of his companion and that of other French sanitarians and engineers, that it was possible to purify raw water from the River Seine so as to make it bacteriologically safe. It was interesting to observe that those experiments were commented on by the French press as experiments along an entirely new line, and so far as one could gather from those comments, the use of liquid chlorine in the United States for a long period of years prior to that time was not known in France. Not only did this seem to be true of the press in general, but the speaker had an opportunity to examine a number of reports on water sterilization for different municipalities by prominent French engineers and sanitarians; and although they gave consideration in their reports to the use of ozone, ultra-violet rays, and similar processes, he did not see any mention of the use of liquid chlorine. The impression made by Lieut.-Col. Bartow's experiment was so excellent that as a result it was possible to introduce liquid chlorine disinfection into a number of municipal supplies upon which the American Army depended.

THE UNAFLOW PUMPING ENGINE[1]

By D. A. Decrow

The Unaflow steam engine derives its name from the fact that the steam travels over a path into and through the steam cylinder in one direction; it does not counter-flow or return over its own path. It has sometimes been called "Unidirectional flow" but more commonly "Una-flow," but as the hyphen will ultimately disappear, the word "Unaflow" is now being used to designate this type. This paper is not intended to be highly technical, but rather to be partly historical, partly descriptive and partly anticipatory, interesting in a way perhaps, because it illustrates to a certain extent the various phases of the development of a new type.

The Unaflow engine is not particularly new in principle but its successful development as a practical and economical commercial machine is quite recent and its adaptation to reciprocating pumping engine practice new. A number of inventors during the past thirty or forty years have been attracted by the Unaflow principle but none of them has until quite recently succeeded in perfecting its development so as to make it a successful, economical and commercial production.

While he does not seem to have been the first, J. L. Todd is possibly the most prominent of the early inventors who attempted to apply the Unaflow principle to the steam engine. His first patent was a British patent issued in 1885. He was not able to make it a mechanical or commercial success, though he spent many years and much money in the effort. About 1895 he apparently gave up trying to make a success of the pure Unaflow and adopted the "Dual" or double-exhaust engine, which was a combination of the Unaflow and counter-flow type; he, however, did not appear to have followed the right lines in the development of his Dual exhaust engine to make for unqualified success, for it has not come into general use.

After these early and on the whole unsuccessful attempts, interest in the Unaflow engine died out for a considerable period, but quite

[1] Read before the Buffalo convention June 10, 1919.

recently inventors have been attracted to it and much experimental work has been done; Prof. J. Stumpf took it up actively, overcame previous difficulties and to him undoubtedly falls the honor of making the first practical and commercially successful application of its principles to modern steam engine practice; his inventions and adaptations have been generally recognized. During the period directly previous to the beginning of the late war, many of these Unaflow steam engines were constructed in England and on the continent

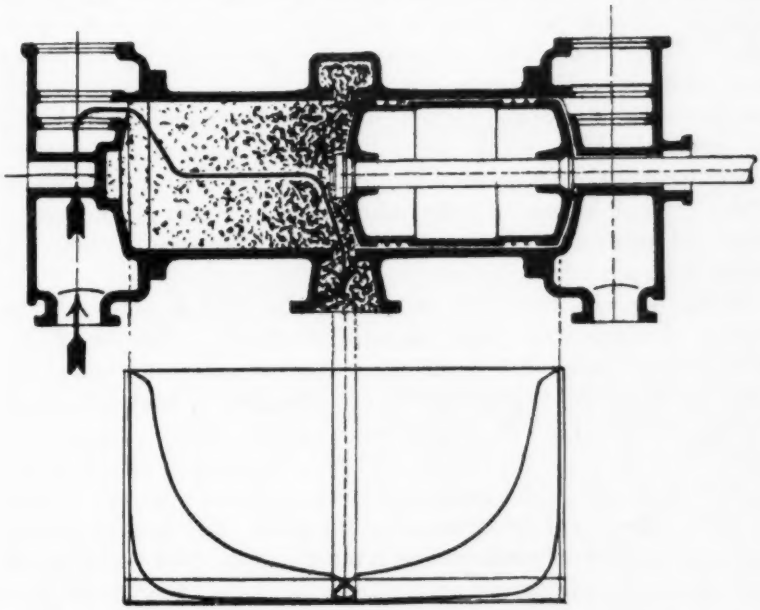


FIG. 1. TYPICAL UNAFLOW STEAM CYLINDER AND INDICATOR CARDS

for various kinds of power service, but in the United States it has not until recently been developed and adapted for power units in conformity with American practice, activity along these lines having been restricted greatly by reason of war requirements on the engineering and manufacturing resources of the country. The war is now over, rapid progress is being made in its development, many power units have been and are being installed and a number are in successful operation.

Broadly speaking the general principle of the Unaflow reciprocating steam engine is that of utilizing the heat energy of the steam in

the cylinder during the period of its admission, expansion and flow in one direction, the expanded steam being released or exhausted through ports or openings uncovered by the travel of the cylinder piston at that period of its stroke most remote from the point of admission; the comparatively cold expanded or exhausted steam does not counter-flow and pass through ports at or near the admission or hot end of the cylinder.

In the accompanying sketch of a typical "Unaflow" engine steam cylinder and indicator cards, the piston is at one end of the stroke with the exhaust ports uncovered. The arrow indicates the path of the steam through the cylinder. The indicator diagram shows that steam is admitted into the cylinder for only a very minor portion of the stroke and is then cut-off, the work performed during the remainder of the stroke being due to the expansion of the steam after the inlet valve closes. The exhaust opens when the piston, which is much longer than the ordinary engine steam piston, travels past and uncovers the exhaust ports midway between the two ends of the cylinder.

Beginning with the steam in the cylinder there is practically no change of temperature until the point of cut-off. After cut-off, expansion takes place with a consequent drop in temperature and at this time condensation begins, due to the changing of heat into work. As the cylinder head is jacketed with high steam no condensation takes place on the walls of the head, but the condensation is on the wall of the piston, which is comparatively cool, and adjacent thereto, so that at the end of the stroke when the piston uncovers the exhaust ports the moisture of condensation is mostly at the exhaust end of the cylinder, and as the steam expanding away from the cylinder head rushes out through the exhaust port, it carries the moisture with it.

At this time there is a sudden drop of temperature in the cylinder due to the sudden drop of pressure, but as the inlet end of the cylinder is dry it does not lose its temperature, the flow of heat from a dry surface being slow and there is not sufficient time for any perceptible drop in temperature of these dry walls. The exhaust port is covered by the piston on the return stroke, trapping in the cylinder comparatively dry steam partially superheated; as the walls of the cylinders have retained their heat, the heat of compression is not absorbed either by moisture or by cold walls, as in the case of a counterflow engine, and the steam remaining in the clearance is heated by compression to a temperature above the temperature of the initial steam;

when the valve is opened to start the next stroke the live steam rushing in goes into a clearance space in which the steam entrapped is hotter than the entering steam, hence no initial condensation. Owing to the complete removal of all of the mixture of each stroke, the well known heat losses caused by the presence of water in counterflow engines are avoided.

Eliminating initial condensation permits an economical high ratio of expansion in one cylinder. For normal working conditions about sixteen expansions have been found to give best results.

It is also evident that with the use of exhaust ports in the cylinder instead of the usual exhaust valves, leakage losses at the exhaust valves and the losses due to all of the added clearance space and surfaces which necesarily follow from the use of a special exhaust valve, are eliminated. It has been found practical to reduce the clearance space in condensing engines to 3 per cent of the swept volume of the piston.

Some of our manufacturers of Unaflow steam power engines have guaranteed as low as 10 pounds of steam per indicated horse power per hour, and some of the tests of European built engines have shown well under 9 pounds.

Taking into consideration its simplicity, for with a single cylinder substantially the same economy is obtained as with the best types of compound or triple expansion steam engines, the Unaflow engine marks a distinct step in advance of the other types of reciprocating engines. These advantageous features have attracted attention to its desirability as a motive power for reciprocating pumping engines.

To develop a pump that could be combined with and utilize the advantageous features of the Unaflow engine requires that due consideration be given to proper channels for passing the desired amount of water to and through the pump with the least practicable amount of deflection and disturbance of the flow. This can best be attained by incorporating the Unaflow principle in so far as it will apply to a pump. The pump should be provided with passages ample and direct so there will be no reversal of flow, with plungers properly proportioned and formed to cause a minimum disturbance, with suitable suction and discharge air chambers properly located, with pump valves that will deflect the direction of flow as little as possible, that will operate quickly and quietly at all pressures and economic speeds of the engine, and furthermore, that will be durable and lasting in operation.

One of our pumping engine manufacturers has designed, constructed, erected and will operate in the Porter Avenue water works pumping station of the City of Buffalo, especially for the inspection and information of the members of this convention, a complete Unaflow high-duty condensing pumping engine of about 3,000,000 gallons daily capacity.

It was intended at the time it was decided to construct this pumping unit, to not only have it ready for operation, but also to have completed a series of tests of its efficiency with the results properly tabulated; but war and other work was so pressing it was not found practicable to do this latter. These tests will be made later and the results published; they will be comprehensive and thorough, both as to normal working conditions, and as to variations in capacities and pressures, in order that accurate economy curves may be constructed. It is anticipated that the tests will show a very high duty and that a flat economy curve will be obtained. The installation is shown in figure 2.

This engine is of the horizontal extended type (so called), having one steam cylinder and one double acting plunger pump; its normal working water pressure is 100 pounds per square inch; the suction left is approximately 15 feet plus the friction in about 60 feet of suction pipe; these are not particularly favorable working conditions, rather the reverse. The engine may be duplex or triplex which would double or triple its capacity, it also may be of the opposed or interposed types, horizontal or vertical. The normal steam pressure at the Porter Avenue Station is 235 pounds per square inch with 100° F. superheat.[2]

The outstanding features of the Unaflow pumping engine are: Simplicity of construction; low cost of production as compared with compound and triple expansion reciprocating pumping engines; high duty or economy in the use of steam not only in the large but also in the small units. For instance, the 3,000,000 gallon unit above mentioned is expected to develop a duty of 180,000,000 foot pounds per 1000 pounds of steam, and to maintain this duty more nearly under variable loads than any other known type.

[2] In the brief discussion of the paper the author stated that the valve lift was 0.3 inch and that the velocity of flow through the valves was 3 feet per second when the pump was delivering 3,000,000 gallons. The operation of the pump at various speeds was witnessed by the members of the Association during the convention.—*Editor.*

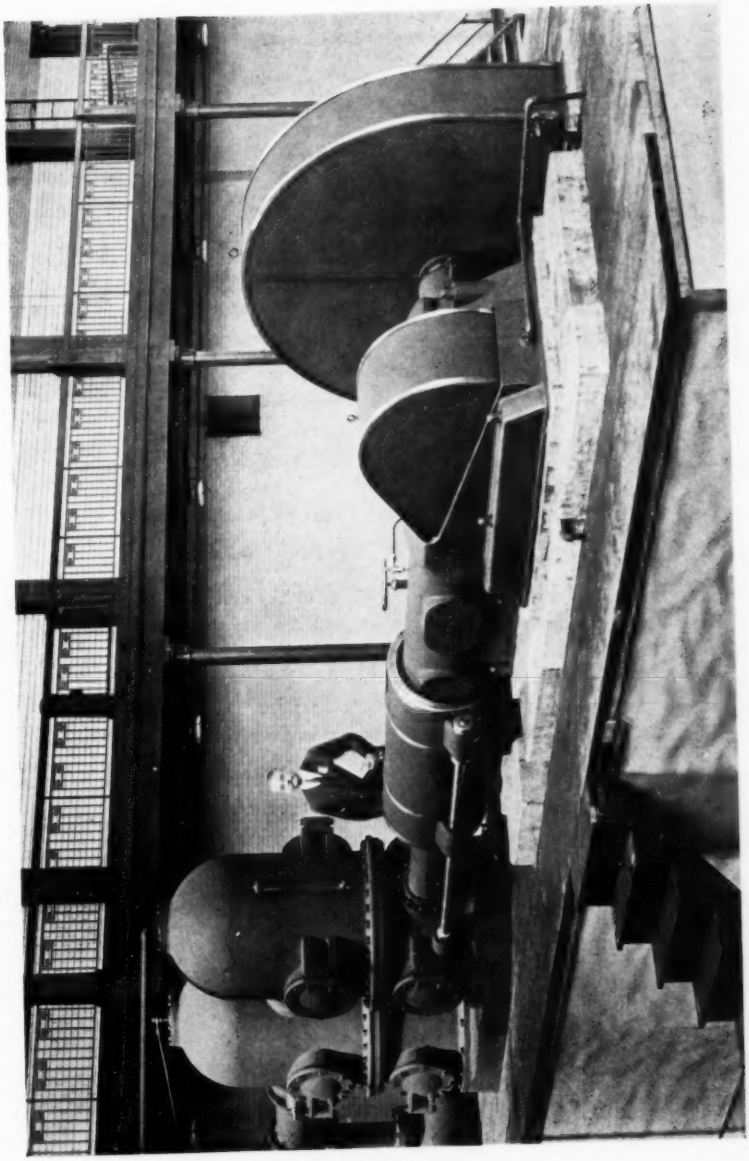


FIG. 2. A UNAFLOW HIGH-DUTY CONDENSING PUMPING ENGINE

BUFFALO'S WATER SUPPLY, WITH SPECIAL REFERENCE TO THE FILTRATION PROBLEM[1]

By Henry F. Wagner

The present water works system of Buffalo has been developed from plans made in 1905 by the engineers of the Board of Public Works of the city, subsequently approved, with a few minor suggestions, by an engineering commission consisting of Gen. George S. Field, Col. Thomas W. Symons and Dr. Rudolph Hering. At that time the supply was drawn through an intake in the Niagara river to what was originally known as the Front Avenue pumping station, a plant which was seriously overloaded. The intake crib was about 1000 feet from the shore line, at a point where the water was 16 feet deep. Water taken from this intake was considered at that time to be approaching a condition where filtration would be necessary; it should be recalled that in 1905 the usefulness of chlorination as a method of treating water supplies was unknown. It seemed best to abandon the proposed enlargement of the old intake, which would be a very costly undertaking, and to construct a new intake tunnel to what is known as the Emerald channel at the foot of Lake Erie, and to build a new pumping station. The relative location of these works is shown in figure 1. Measurements of the currents in this part of the lake showed that the polluted water moves along each shore and the water coming from the unpolluted lake moves toward the head of the Niagara River in the Emerald channel. As a supply of fair quality was then obtainable through the old intake, it was determined to retain it in service and to reconstruct the Front Avenue station. This was done without interrupting the service, a piece of work which aroused much praise from those who saw it in progress. The old station is now known as the Massachusetts Avenue station and is connected by a shore tunnel with the new intake, so that it can pump water from the Emerald channel.

The Niagara River inlet up to 1914 was the only source of supply.

[1] Read before the Buffalo Convention June 10, 1919.

It was first built in 1870, enlarged in 1895 and reconstructed in 1906. The current here is from 8 to 10 miles per hour and it was thought that a pure water would be obtained. The structure itself was quite a notable one for that period. Its foundation is laid upon the bed rock of the river and extends upstream for about 25 feet in a triangular-shaped mass of stone and cement, to break the force of ice floes which strike here with considerable force. This intake was intended to supply the reconstructed pumping station at Massachusetts Avenue, but during the last few years of its use it proved wholly inadequate for the rapidily growing demands upon it. In

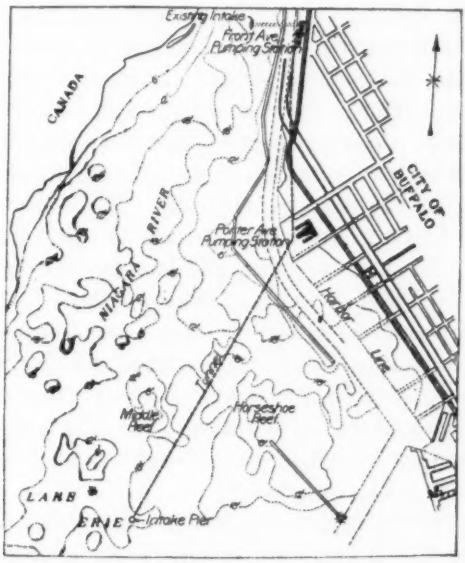


FIG. 1. BUFFALO INTAKES AND PUMPING STATIONS

the winter and spring, when ice was running in the river, it often became plugged with slush and anchor ice so that gangs of 200 to 300 men were required to work with shovels, scoops and steam lines in order to maintain the water level in the suction well. This supply also often became heavily contaminated by the harbor waters. Since the new Emerald channel inlet was completed, the old intake has been abandoned.

The Emerald channel intake, started in 1905 and completed in 1914, is a circular structure with an outside diameter of 110 feet.

The enclosing wall is of concrete 20 feet thick, leaving an interior chamber 70 feet in diameter. From the bottom of the lake and extending 2 feet above the mean water line, concentric steel shells $\frac{3}{8}$ inch thick incase the concrete wall inside and out. This wall extends 15 feet above the lake level. On the top, and set back 5 feet from the edge leaving a balcony clear around, is a brick wall 8 feet high. An ornamental iron railing encircles the balcony. The whole interior is roofed over half way with concrete covered with tile and the rest with heavy glass, all supported by steel trusses. The water is admitted into the interior chamber by twelve 6 by 6-foot ports, which are opened and closed by steam-operated gates. It has been found, however, that by keeping them open and thus lessening the force of the current flowing into the interior, there is less danger of anchor and slush ice plugging the gates. By this practice there is scarcely any perceptible current and the water is at lake level. In the center there is a shaft 12 feet in diameter which extends 60 feet below the surface and connects with and carries the water to the tunnel leading to the pumping stations. This is a 12-foot arched tunnel driven through limestone rock and has an 18-inch concrete lining. This tunnel is intercepted on shore by a second shaft, from which part of the water flows to the pumps at Porter Avenue by open canals and the rest is carried by a 9-foot tunnel to the Massachusetts Avenue station. There are installed on the pier, two 100 horse power boilers for furnishing heat and running a 10-kilowatt generator unit, which provides current for lighting the building including the fixed signal light which the government requires to be maintained as an aid to navigation.

The Massachusetts Avenue station is 640 feet in length and 102 feet in width. It houses six 30,000,000 gallon vertical triple-expansion pumps and two electric pumps of 25,000,000 gallons each. The electric pumps have been in disuse for several years and it is not expected that they will be put in operation again. The steam pumps are operated with 150 pounds of saturated steam which is produced by 16 horizontal tubular boilers of 300 horse power each and four water tube boilers of 600 horse power each. At the present writing but one pump at this station is in operation. The others, however, can be thrown into service at short notice should they be required.

The bulk of the water is supplied by the new station at Porter Avenue which was put into operation in 1914. This plant is one

of the largest of its kind under one roof and was constructed and equipped at a cost of about $2,500,000. The engine room is 95 by 364 feet and foundations are laid for eight pumps. Up to the present time five have been erected and are in use. The boiler room has space for sixteen boilers; eight are installed at present. They are the sectional water tube type of 750 horse power. High-pressure steam is utilized at this station at about 250 pounds and 100° of superheat. The total pumping capacity of the two stations is about 380,000,000 gallons and by the addition of three more pumps it is possible to furnish over 400,000,000 gallons of water.

The distribution is through two systems, the high and low. The initial pressure on the high-service ranges from 80 to 90 pounds and on the low-service 42 to 50 pounds. The high-pressure system in general takes care of the newest sections of the city, while the low supplies the older sections. In all, water is distributed through over 600 miles of pipe which range in size from $1\frac{1}{2}$ to 60 inches.

There is located in the northeastern section of the city a steel water tower 40 feet in diameter and 85 feet in height, figure 2. It stands on an elevation of 106.31 feet above the lake level and when filled to a depth of 75 feet holds 704,970 gallons. In the eastern sections of the city there is the Prospect reservoir, which covers 20 acres and when filled to a depth of 30 feet holds 116,313,827 gallons. At this stage the water surface is 113 feet above the pumping station. The tower is supplied by the high-service and the reservoir by the low, and by keeping the water in them at certain levels, a constant and uniform pressure is obtained throughout the city. In other words, the speed of the pumps and number in use at any time are dependent upon the height of the water in these reserve sources of supply. This information is telephoned to the pumping stations every half hour and action taken thereon accordingly.

As to the purity of the water supply, the author believes he is quite safe in saying that without any treatment at all it is as good as any available to cities having Lake Erie as their source of supply. The greatest contamination occurs during the summer months and a large part of it is due to freight and passenger vessels which generally use the north channel entrance to Buffalo harbor, which course takes them within less than 1000 feet of the inlet crib and on the upper side. Upon the opening of the summer resorts a short distance above, on the Canadian shores, several excursion boats ply back and forth from Buffalo hourly. These boats carry thou-

FIG. 2. THE KENSINGTON WATER TOWER

sands of people daily and with no restriction on the disposal of their sewage. This constitutes a great menace, as excreta from this source may easily pass into the water supply in a fresh and virulent state. The shore drainage adding to the pollution, while considerable, is not necessarily excessive, as there are no cities of any size above Buffalo whose sewage might find its way into the water supply. There are several streams flowing into the lake within easy radius of Buffalo but they are small and the tendency is for their water to follow inshore, as the extensive use of floats has proven. In the winter, after navigation closes and especially after the ice has formed, the water is of a most excellent quality. The bacteria count obtained on 37° agar is then very low. There is one aspect, however, which has to be given weight and that is with reference to the condition arising as a result of the hundreds of fishermen who go out on the ice to fish. The excreta which these people leave upon the ice is a constant menace to the water supply, more so at thaw periods and acutely so when, upon the coming of spring, the ice breaks up and all is carried in the direction of the crib. It can be seen, therefore, how most of the contamination occurs at uncertain periods. This condition makes it necessary for chlorine to be added to the water in sufficient quantity to take care of the high wave at all times, even though the dose may be in excess of that actually essential during three-fourths of the time.

The chlorination apparatus is located at the intake pier where the chlorine solution is injected into the mouth of the 12 foot arched tunnel. This, therefore, affords a run of over a mile in a leak-proof tunnel and ideal conditions for sterilization. The apparatus is of the float meter type. The float is about 3 inches long and has never caused any trouble from sticking, as has been the case where the small indicator was used. The chief trouble with this apparatus has been caused by the clogging of the pressure reducers, which requires taking them apart every once in a while and cleaning them. Generally it is necessary to replace the old diaphragms with new ones when this is done.

The amount of chlorine used ranges from 0.16 to 0.28 part per million. These figures are equivalent to about 1 pound and 2½ pounds per million gallons.

The author does not believe in any set and fixed standard for a safe water. In other words, the same standard is not applicable to any two waters, and when such is aimed at there is certain to be a

variation one from the other in actual practice. A set standard will be hard to abide by, because of the great difference in the kind and character of the pollution. While the standard may be too severe in some cases it may not be severe enough in others and therefore misleading. A standard is no sooner proposed for certain conditions than it is at once grasped and applied to a great variety of conditions. The Buffalo standard is that the bacteria count made on 20° agar is a gauge of the efficiency of the sterilization plant and means nothing as to whether the water is safe or not. The real knowledge is obtained from the test for organisms of the B. coli group. The author prefers to use lactose peptone bile as a medium. His aim is to eliminate gas formers to the extent that negative tests are obtained on four out of five 5 cc. samples of the treated water.

It is evident that Buffalo has an excellent water system. Physically the condition of the water is open to severe criticism from 10 to 15 per cent of the time, which brings up the subject of filtration. A glance at a map will show that Lake Erie lies to the west or southwest from Buffalo. It is from this direction that the winds come which prevail principally during the fall when the highest turbidity occurs. Compared to some water, this is not at all bad, as 250 parts in a million is about the maximum. It consists principally of very finely divided clay, the percentage of organic matter being very small. Generally the sediment is offensive for from three to six days at a time. The sediment is quite heavy and settles rapidly as soon as the disturbing element is removed; the second day after a blow the water has improved 50 per cent. In all, the water is noticeably turbid from thirty to sixty days of the year.

In planning for a filtration plant in Buffalo, consideration must be given to the following points. First, do the prevailing conditions of the water set forth warrant such an expenditure? Second, the water consumption must be reduced to a reasonable figure and waste to a minimum before such a project is feasible. Lastly and perhaps the most difficult problem is the suitable location for a filter plant. When the water works were originally laid out it seems the idea that Buffalo might some day have such a plant was not thought of or at least no provision was made for its possible location. As to the proposition that the water be pumped to an elevation outside of the city and returned by gravity, the city is handicapped by the flat nature of the country around it. To

secure an elevation anywhere near sufficient for the purpose it would be necessary to go at least 15 miles into the country. The enormous expense that would be incurred securing the right-of-way and in constructing a dual pipe line of the size which would be sufficient for the purpose would place too heavy a burden upon the resources of the city of Buffalo.

A solution of this problem will probably be found to the south of the Porter Avenue pumping station where there is a large tract of water-front land which is at present used for a dumping grounds. Part of this land is covered by the harbor waters but can be easily reclaimed by a retaining wall and subsequent filling in. This would furnish a location all that could be desired for a rapid sand filtration plant. The water could be diverted to the filters by short extensions to the existing canals and raised to the required height by low-duty pumps. After passing through the filters the water would be permitted to return to the original suction wells by gravity and be distributed through the present system.

NOTES ON THE WATER SUPPLIES OF ARMY CAMPS, CANTONMENTS AND POSTS IN THE UNITED STATES, WITH PARTICULAR REFERENCE TO PROBLEMS OF QUALITY[1]

By Major Charles Gilman Hyde and Capt. Charles A. Haskins

The expansion of the military establishment following our entrance into the war necessitated an immense program of building in order to provide housing and accommodations for the new army during its organization and training. The first plans provided for 32 camps divided into two classes, 16 for the accommodation of drafted men, designated as national army camps, and 16 for the accommodation of the federalized state militia, designated as National guard camps. It was presumed that the period of the occupancy of the latter would be relatively short on account of the advanced training of the national guard, and they therefor were not constructed in as permanent a manner as the national army camps. Consequently they were generally located in the southern portions of the country in order to take advantage of the milder climate. They were commonly known as tent camps, and were not provided with water-carriage sewerage systems, heating plants, laundries, and other conveniences, and their water works plants and water distribution systems were not designed in as generous a manner as were those of camps of the first class.

Before the completion of any of the original 32 camps it became apparent that there were many other projects necessary to be undertaken, such as extensions to the camps then being built, the enlargement or improvement of many regular army posts, the construction of additional camps for special training purposes, the erection of quartermaster and ordnance depots, port terminal facilities, chemical warfare camps, explosive plants, the construction of new hospitals and the improvement or remodeling of privately owned buildings taken over for hospital purposes, and many other miscellaneous pieces of construction.

[1] Presented at the Annual convention at Buffalo, June 9–13, 1919. Authority to print granted by the Board of Publication, Surgeon General's Office, U. S. A.

It is estimated that the separate projects handled in the United States by the War Department reached a total number in excess of 600. Many of these projects included complete water works plants and sewer systems. Whenever possible the water supply of nearby cities was utilized, and, when necessary, sufficient aid was given by the government to the cities or to the companies operating the plants, for the rehabilitation or the enlargement of their works, so that the desired service could be furnished. In addition to the projects undertaken by the War Department organizations, there were many others of similar nature undertaken by the Navy Department, the Shipping Board and the Housing Corporation.

The construction problem in general. It is difficult to realize the magnitude of the problem with which those in authority were confronted in April, May, June and July, 1917. There was little or no knowledge of the sites on which many of the camps were to be built, of their topography or of their distance from transportation lines. The ultimate size of the company and regimental units was not even known, (on account of changes which had been proposed in order to coordinate our army with those of the Allies) although it had been decided that each camp should house one infantry division and certain other special troops. It was proposed to call the first draft to camp about September 1, and it was necessary to have ready for them at that time not only the 1200 to 1500 buildings needed, but to have complete and reliable utilities including water supply, sewerage and electricity. This necessitated the complete construction of 32 new cities, each of from 30,000 to 40,000 population, beginning with the clearing of the site and carried through to the completed project, in the short time of about ninety days, and it was also necessary to provide temporary shelter and accommodations, including water supply, for a large number of workmen at each camp, during the construction period.

Upon the declaration of war in April, 1917, the Council of National Defense was formed, and various committees of this Council immediately co-operated with the then small Cantonment Division of the army, which had just been formed from the Construction and Repair Division of the Quartermaster General's Department, in the preparation of typical plans for camps, buildings and utilities, the selection of contractors and engineers, and many other matters pertaining to the construction work at hand. A constructing quartermaster for each camp was appointed and a civilian engineer from

the same general locality as the camp, who was familiar with local conditions, was chosen as assistant to the constructing quartermaster. He was given the title of supervising engineer.

After the actual choosing of a camp site, which in the cases of most of the earlier camps was done by the commanding officer of the department in which the camp was to be located, assisted by a board of officers of the regular army, the constructing quartermaster and the supervising engineer fitted the typical plans with which they had been furnished to the proposed site. They also reported upon the available sources of water supply, the best means of disposing of sewage and upon all other features of the camp of an engineering nature. Advisory engineers, stationed in the Washington Office, in general charge of various portions of the work, had been appointed in the Cantonment Division. Through the co-operation of all of these men the camps were developed and constructed.

During this period aviation camps were being established and constructed, independently of the Cantonment Division, under the supervision of the Buildings and Grounds Section, Department of Military Aeronautics. Their water supply, sewerage, sewage disposal and similar problems were usually handled by the engineers from that department, assisted by civilian engineers generally chosen from the vicinity of the camp. Many special training camps, and other camps for specific purposes were soon established and under way, usually under the supervision of the Cantonment Division, which meanwhile had been separated from the Quartermaster Corps and reorganized as an independent branch of the army under the name of Construction Division. The utilities of these later camps were in most cases designed and constructed entirely under the direction of representatives of this division. Many of the camps, plants and hospitals were unsatisfactorily located from the standpoint of sanitation, and their water supply, sewerage and drainage problems were unusually difficult, but the sites were considered by those in authority so advantageous from other standpoints that the sanitary objections were overruled.

Sources of water supply utilized. The first camp sites were chosen as stated before, by the commanding officers of the department in which they were to be located, assisted by a board of officers upon which there were supposed to be five men, including an engineer, a medical officer, a quartermaster corps officer and two line officers, but the boards which passed upon the numerous sites offered did

not in all cases have a complete representation, and the inspections in many cases were made by only one or two of the officers of a board. In several cases, the recommendations of the officers assigned to this duty were ignored by the department commander and camp sites were chosen over the objections of the board. A great many features required consideration in connection with the choice of the sites. Of these sanitation, including water supply, sewerage and drainage, although of recognized importance, was only one. Therefore in many instances the problem was considerably complicated and it was necessary ultimately to choose sources of water supply which would not have been considered, had sites, more appropriate from this standpoint, been selected, or had more time been available for prospecting for or for the development of, other sources of supply. This was the case, for instance, at Camp Dix, where one of the strong arguments advanced for the site near Wrightstown was the abundant supply of wholesome well water, said to be easily available in the vicinity of the camp. After a hurried but capable investigation by experts, a supply of easily purified surface water from Rancocas Creek of undoubted adequacy was chosen rather than an apparently limited supply from wells. At Camp Pike also, the city supply of Little Rock with the Arkansas River as its source, necessitating 6 miles of pipe line and two booster stations to get the water into the camp, was chosen rather than risk the development of a ground water supply, which probably would have been highly impregnated with iron, although available in a somewhat closer location to the camp.

In all there were 48 large camps. This number includes the original 32 national army and national guard camps, 9 special training camps, 3 embarkation camps, 3 port terminals and one large arsenal. This number does not include any of the aviation camps, ordnance plants, or numerous other camps and plants of smaller size. Data concerning the ownership and the general source of supply, whether ground water or surface water, are shown in tables 1 and 2. Information of the same sort concerning 21 other smaller training camps, proving grounds, ordnance or other plants is shown in table 3. This latter list is by no means complete but represents principally those places in which some work was done by officers of the Sanitary Corps. Table 4 contains the same data for all of the general hospitals and table 4 A for all of the aviation camps.

Bearing in mind the fact that the original intention was that the national guard camps should be of more temporary character than

TABLE 1

Data relating to ownership and type of source of water supply of original 32 national army and national guard camps

SUPPLY FROM GOVERNMENT PLANT		SUPPLY FROM NEARBY MUNICIPALITY	
Ground water	Surface water	Ground water	Surface water
Beauregard*	Dix§	Cody* (Deming, N. M.)¶	Bowie* (Ft. Worth)‡‡
Custer	Meade	Fremont* (San Francisco)**	Doniphan* (Lawton)
Devens†		Logan* (Houston, Tex.)††	Gordon (Atlanta)
Dodge		McClellan* (Anniston)	Greene* (Charlotte)
Funston		Sheridan* (Montgomery)	Hancock* (Augusta)
Grant		Travis, San Antonio	Jackson (Columbia)
Lewis			Kearney* (San Diego)§§
Shelby*			Lee (Petersburg)
Sherman‡			McArthur* (Waco)¶¶
Upton			Pike (Little Rock)†††
			Sevier* (Charlotte)
			Wadsworth* (Spartanburg)
			Wheeler* (Macon)***

* Indicates national guard camps.
† Emergency connection to Ayer waterworks (ground water).
‡ Emergency connection to Chillicothe waterworks (ground water).
§ Auxiliary well supply for boiler use and for base hospital.
¶ 2 wells owned by United Land and Water Company.
2 wells owned by Government.
** Camp distribution system connected to Bear Gulch reservoir.
†† Auxiliary wells owned by Government.
‡‡ Main supply from Lake Worth. An auxiliary well supply is available.
§§ Auxiliary supply from wells.
¶¶ Forty per cent of water from Brazos River, 60 per cent from wells.
*** Auxiliary supply from Stone Creek.
††† Auxiliary well supply.

TABLE 2

Data relating to ownership and type of source of water supply of miscellaneous large army camps constructed after the completion of the original 32 camps

SUPPLY FROM GOVERNMENT PLANT		SUPPLY FROM NEARBY MUNICIPALITY	
Ground water	Surface water	Ground water	Surface water
Eustis	Benning	Mills*	Charleston port terminal
Johnston	Bragg		Forrest, Greenleaf } Chattanooga†
Stanley	Edgewood		Las Casas (San Juan)
	Knox		Merritt (Hackensack Water Co.)
	Humphreys		Newport News
			1. Alexander
			2. Hill
			3. Morrison
			4. Stuart
			Norfolk Port Terminal

* Government owned ground water supply was developed in 1919.
† Auxiliary supply from Fort Oglethorpe, wells.

TABLE 3

Data relating to ownership and type of source of water supply of miscellaneous small camps and plants

SUPPLY FROM GOVERNMENT PLANT		SUPPLY FROM NEARBY MUNICIPALITY	
Ground water	Surface water	Ground water	Surface water
Aberdeen Proving Grounds	Muscle Shoals	Willoughby	Colt (Gettysburg)
Curtis Bay Ordnance Depot	Perry	Hastings	Crane (Allentown)
Holabird	Summerall	Raritan	Jessup (Atlanta)
Kendrick			Kingsport (Kingsport)
Normoyle			Laurel (Laurel)
Pig Point Arsenal			Leach (Washington)
Robinson			Meigs (Washington)
Savannah Proving Grounds			Syracuse (Syracuse)

This list is by no means complete but it is believed that the more important of the small plants are included.

TABLE 4

Data relating to ownership and type of source of water supply of aviation fields

SUPPLY FROM GOVERNMENT PLANT		SUPPLY FROM NEARBY MUNICIPALITY	
Ground water	Surface water	Ground water	Surface water
Barron, Ft. Worth, Tex.	Langley, Hampton, Va.	Arcadia Balloon School, Cal.	Bolling, Washington, D. C.
Carlstrom, Arcadia, Fla.	Selfridge, Mt. Clemens, Mich.	Brooks, San Antonio	Call, Wichita Falls, Tex.
Carruthers, Ft. Worth, Tex.	Ground water	John Wise, San Antonio	Vail, Tintern Manor, N. J.
Dorr, Arcadia, Fla.	Taliaferro, Ft. Worth, Tex.	Chanute, Rantoul, Ill.	Hazelhurst, Garden City, L. I.
Eberts, Lonoke, Ark.	Taylor, Montgomery, Ala.	ARD, Montgomery, Ala.	Post, Lawton, Okla.
Ellington, Houston, Tex.	McCook, Dayton, Ohio	Houston GSD, Tex.	Rich, Waco, Tex.
Gerstner, Lake Charles, La.	MiddletownAGSD Pa.	Emerson, Columbia, S. C. (not city supply)	Rockwell, Coronado W. Co. (San Diego)
Lee Hall Balloon School, Va.	DaytonWarehouse Ohio	Kelly, San Antonio	Scott, E. St. Louis, Ill.
Love, Dallas, Tex.	ARD, Dallas, Tex.		Morrison, ASD, Newport News, Va.
March, Riverside, Cal.	ARD, Indianapolis	Surface water	Omaha Balloon School, Omaha, Nebr.
Mather, Sacramento, Cal.	Detroit Acceptance Park, Mich.	Chandler, Essington, Pa.	Little Rock Warehouse, Ark.
Miami AGS, Fla.	Rockwell Park, Wilmington, Del.	Buffalo Acceptance Park, N.Y.	Elizabeth, N. J. Acceptance Park
Mitchell, L. I.	Dayton Acceptance Park, Ohio	Penn, Austin, Texas	
Park, Millington, Tenn.	Dayton GSD, Ohio	Richmond Warehouse, Va.	
Payne, West Point, Miss.	Garden City, ASD, L. I.		
Souther, Americus, Ga.			
Wilbur Wright-Fairfield, Ohio			

TABLE 4A

Data relating to ownership and type of source of water supply of army general hospitals

GROUND WATER			SURFACE WATER		
Number	Place	Ownership	Number	Place	Ownership
	Hot Springs, Ark.*	City of Hot Springs		San Francisco*	Government
	Ft. Bayard, N. M.*	Government		Walter Reed, Washington*	District of Columbia
9	Lakewood, N. C.	Lakewood Water Co.	1	Williamsbridge N. Y.	New York City
11	Cape May, N. J.	City of Cape May	2	Ft. McHenry*	Baltimore
14	Ft. Oglethorpe*	Government	3	Colonia, N. J.†	Middlesex Water Co.
25	Ft. Benj. Harrison*	Government	4	Ft. Porter, N. Y.*	City of Buffalo
26	Ft. Des Moines*	Des Moines, Ia.	5	Ft. Ontario, N. Y.*	City of Oswego
29	Ft. Snelling, Minn.*	Government	6	Ft. McPherson, Ga.*	City of Atlanta
34	East Norfolk, Mass.	Leased	7	Roland Park, Md.	Baltimore Co. Co.
SURFACE WATER			8	Otisville, N. Y.	New York City Hospital
			10	Boston, Mass.	Metropolitan District
38	East View, N. Y.	City of New York	12	Biltmore, N. C.	City of Asheville
40	St. Louis	City of St. Louis	16	New Haven, Conn.	City of New Haven
41	Fox Hills, N. Y.	City of New York	17	Markleton, Pa.	Leased
42	Spartanburg, N. C.†	City of Spartanburg	19	Oteen, N. C.	Asheville
			21	Denver, Col.†	City of Denver
			22	Philadelphia	Philadelphia
			24	Park View, Pa.	Pittsburgh
			28	Ft. Sheridan, Ill.*	Government
			30	Plattsburg Bks.*	Plattsburg W. Co.
			31	Carlisle, Pa.	City of Carlisle
			32	Chicago, Ill.	City of Chicago
			35	West Baden, Ill.	Leased
			36	Detroit, Mich.	City of Detroit

* Indicates regular army hospitals or permanent army posts utilized for hospital purposes.

† Indicates new establishment constructed by Government.

the national army camps, it is interesting to note that ten of the sixteen nationl army camps were supplied by new plants designed and constructed by the War Department, while the remaining six were supplied by existing plants of the nearby communities. Only two new plants were constructed for the National Guard camps, the remaining fourteen being supplied by plants of the nearby communities.

Scope and nature of the present discussion. The immediate purpose of this paper is to present a more or less general statement concerning the quality of the water supplied to troops in the camps in the United States, the agencies and the methods utilized for safeguarding the supplies and the results which were obtained. The subjects of quantity and dependableness will be touched but briefly, because, while these two attributes of a satisfactory supply have close relations to the quality, there were only a few instances where an abundant supply was not available at all times and the shortages which were experienced were of brief duration only.

The material presented herewith has been collected from many different sources, principally from monthly and special reports of camp sanitary engineers, the reports of sanitary inspections made by medical officers of the Division of Sanitation of the Medical Department, and the monthly sanitary reports made by the camp sanitary inspectors. Material from these sources has been supplemented by information gained through special investigations by the authors or other officers of the sanitary engineering section of the Surgeon General's Office and through official and unofficial correspondence with various persons and various branches of the service, particularly the Construction Division.

Relation of the Medical Department to the water supply problems. The army regulations charge the Medical Department "with the duty of investigating the sanitary condition of the army and making recommendations in reference thereto," and further "of advising with reference to . . . . . the adoption of systems of water supply and purification . . . . . etc." They further provide that "the surgeon of every post or command, under the direction of the commanding officer . . . . . will examine, at least once a month, the amount and potability of the water supply . . . . ." The reports of such examinations are received by the Surgeon General. They constitute a portion of the monthly sanitary reports referred to above.

A group of specially trained medical officers of long service, at-

tached to the Division of Sanitation, Office of the Surgeon General, is constantly engaged in making routine and special inspections and reports of all large camps, cantonments, hospitals and other stations, their duties pertaining chiefly to sanitary and administrative matters. Great stress is laid by these officers on matters largely technical, including among other things general camp sanitation, water purification and sewage disposal.

The Sanitary Corps of the army was authorized by the President on June 30, 1917, under the Medical Department and it was organized shortly thereafter. Officers were commissioned in this corps who were found "to possess special skill in sanitation, in sanitary engineering, in bacteriology or other sciences related to sanitation and preventive medicine . . . . . etc."

The sanitary engineering section of the Sanitary Corps is composed of officers and enlisted men who have had special training in sanitary engineering and public health administration. In general the personnel of the section has been distributed in three groups; (a) those on duty in the Division of Sanitation, Surgeon General's Office; (b) those stationed at camps, cantonments and other commands in the field, and (c) those in overseas service as commanding officers of sanitary detachments and sanitary squads, water tank trains, on special duty with water supply companies of engineer regiments and in laboratory and other special work.

Those officers on duty in the Surgeon General's Office have acted as consultants, advisors and field inspectors on questions relating to water supply and its purification, sewerage and sewage disposal; drainage and mosquito control operations; the disposal of garbage, manure and camp wastes and other similar problems of sanitation.

The duties of the camp sanitary engineer are specified in a circular of the War Department as follows:

> The Sanitary Engineer is an assistant to the camp surgeon and his duties ordinarily shall be:
>
> (a) To inspect and supervise the operation of water supply, sewage and garbage disposal systems, and to advise the utilities officer and subdepot quartermaster with reference thereto; to recommend such suitable standards of performance of these systems as will properly conserve the interests of health and sanitation in the camp and its environment.
>
> (b) To have immediate charge, under the camp surgeon, of drainage, oiling and other preventive measures for the extermination of mosquitoes and flies.
>
> (c) To act as consultant and advisor to the camp surgeon on all the engineering or structural phases of the camp or station which bear a definite relation to health and sanitation.

(d) To perform such other sanitary duties as may be designated by competent authority.

(e) To render a monthly report to the Surgeon General of the army, through military channels, covering such subjects as may be prescribed by the Surgeon General.

Other officers of the Sanitary Corps have been on duty in the field in charge of mosquito and fly control work, in charge of drainage survey parties and as water and sewage plant operators. At some camps and in some municipalities supplying water to camps, these officers were directly in charge of the operation of the plants, although that duty as respects these government plants was usually performed by officers of the Utilities Branch of the Construction Division.

Consideration given to problems of quality in connection with development and construction of water works. The importance of a safe and an aesthetically satisfactory water supply was realized all through the planning and the development of the camps, and particular emphasis was laid on these features in the original instructions for choosing camp sites, issued to the department commanders by the Chief of Staff. As explained before, these matters were occasionally overruled and camp sites were chosen with unusually difficult water supply problems, but in each instance a great effort was made to provide equipment for satisfactorily treating the water in order to secure a safe supply. Willingness to expend large sums of money to accomplish this end was evident, and modern, up-to-date water purification plants were installed at camps where there was any question of contamination of the supply.

Some of the sanitary precautions upon which particular stress was laid by the advisory engineer on water supply of the Construction Division, in addition to the care exercised in the selection of the source of supply and the provision of water purification plants, were described in a recent paper by the advisory engineer on water supply, Construction Division, as follows:

(a) The covering of all storage reservoirs to prevent accidental or intentional pollution and the formation of algae.

(b) The furnishing of chlorinators to all cantonments and camps even when the supply might be regarded as normally safe.

(c) The prohibition of the use of wells in shallow strata on inhabited watersheds or in any other stratum or location in which it might be possible for the wells to become contaminated.

(d) The absolute prohibition of any distribution mains carrying polluted water, whether for fire protection, or industrial or any other use and of any

outlet or fixture from which such water might be drawn or of any arrangement that would permit the later introduction of any such outlet or fixture.

Consideration given to problems of quality in maintenance and operation of waterworks. Upon the completion of the first several of the large camps, the operation of the utilities at each place was undertaken by the camp quartermaster, assisted by a few specially selected officers commissioned directly from civil life for this work and a small group of enlisted men, following out in a general way the procedure which had prevailed for a long time in the regular army establishment. The work became so great and the problems so complicated, however, that in the summer of 1918 a new organization was formed, known as the Maintenance and Repair Branch of the Construction Division, which has since had charge of all the general utilities pertaining to the army, and of the maintenance and repair of all buildings, roads, walks, wharves, and water and sewerage work. This branch is separated from and independent of the Quartermaster Corps. A central office at Washington directs the work of the utilities organization at each camp. A great effort was made to secure a sufficient number of trained engineers and operators for the work.

The operation of the utilities at aviation camps at first was usually supervised by the government superintendent of construction after their completion, but this policy was later changed and maintenance officers were appointed at each post by the commanding officer, from the personnel at the post. He had general charge, with the assistance of the medical or sanitary corps officer, of water supply, sewerage, sewage treatment, etc. and worked under the general supervision of the Buildings and Grounds Section, Air Service Property Division.

The authority for supervision by the Medical Department over the quantity and quality of the water supply, and the duties of the camp sanitary inspector and the camp sanitary engineer, have been previously set forth, and these officers have exercised their functions in full coöperation with the officers of the Maintenance and Repair Branch and with those of the office of the advisory engineer on water supply. They have been available at all times for advice and consultation on all problems of a sanitary engineering nature.

Control of quality of surface water supplies. Twenty-seven of the 48 large camps were supplied with water from surface sources. Of these, fifteen utilized large streams or rivers, nine small streams or creeks and four impounding reservoirs. All of these with three ex-

ceptions, Camps Dix, Doniphan and Sevier, were equipped with rapid sand filters and disinfecting equipment for the treatment of the water. Camp Dix water is treated by chlorination alone, as it is taken from a small stream which is only moderately contaminated but never turbid. Camp Doniphan at Fort Sill, Okla., and Camp Sevier at Greenville, S. C., are both supplied from large impounding reservoirs with watersheds practically uninhabited. Chlorination has rendered the water at each place safe, but the occurrence of growths of microscopic organisms and occasional high turbidities in Lake Lawtonka, from which Camp Doniphan is supplied, has resulted in the installation there of rapid sand filters (1919). All of the government owned surface supplies for the smaller camps, aviation fields and hospitals were equipped with filters, as were practically all of the municipal surface supplies which were utilized by camps of this class.

Careful sanitary surveys were made of all watersheds, limited in the case of the large streams to that area lying within a few miles of the intake, but covering in the case of the smaller streams the entire watershed. Regular patrols of detachments of enlisted men were maintained on the smaller watersheds under the direction of the camp sanitary engineers, and unusual efforts were made, on a scale seldom even approximated in municipal practice, to secure the abatement of conditions deemed prejudicial to the quality of the supplies.

The actual operation of the government owned water works plants was usually conducted by the Maintenance and Repair Branch of the Construction Division, with a close and careful supervision by an officer of the Sanitary Corps. Municipal plants were usually operated by municipal employees with the same close supervision by the Sanitary Corps as was exercised in the case of government owned plants, but in several instances, notably Petersburg, Va., supplying Camp Lee; Augusta, Ga., supplying Camp Hancock; Lawton, Okla., supplying Camp Doniphan, Fort Sill and Post Field; and Watervliet, N. Y., supplying Watervliet Arsenal, the operation was actually performed by Sanitary Corps officers, and in many other instances the plants were supervised or operated under the direction of camp sanitary engineers. The Red Cross and the United States Public Health Service in their extra-cantonment work, also gave much valuable assistance in the operation of municipal plants through their laboratories and sanitary engineers.

Control of quality of ground water supplies. In general the supplies of water obtained from the ground for the use of our army camps

have been subjected to the same rigid tests as are those secured from sources naturally subject to more immediate and dangerous pollution. Where control measures have been deemed necessary, these have been applied in no uncertain fashion.

The difficulty in securing ground water supplies (especially from comparatively shallow water-bearing strata), which will give negative results with presumptive tests for B. coli is known to all experienced sanitary engineers. Such tests are unquestionably too severe in a vast majority of cases, and it is probable that many safe supplies have thereby been condemned and have been abandoned or else have been subjected to unnecessary treatment. Nevertheless, it is apparent that such tests must err on the side of safety and that they have the very real advantage of directing the attention of sanitary authorities to those supplies which do not demonstrate acceptability on that basis. In this way physical and other investigations may be undertaken which will show whether or not such waters are by any possibility subject to pollution and what means of control or remedy should be applied. Doubtless many perfectly safe ground water supplies of our army posts have been regularly or occasionally subjected to treatment by disinfection because of such laboratory findings. However, as stated hereafter, it has been the well defined policy of those having authority in such matters, to take absolutely no known or predictable chances as respects the hygienic safety of any water supply.

The physical conditions and factors affecting the quantity and quality of ground water supplies have received careful attention. Percolating or collecting areas, when not too remote, and geological formations have been investigated and thereby information has been secured in many cases whereby not only has it been possible to forecast the general quantity of water available but the probable quality of such supplies from chemical and bacteriological standpoints has become at least roughly manifest. In this connection the probable time factor or period of time required for water to pass from a collecting point or area to the point or place of withdrawal has been of extreme interest. It is not conceivable that a water passing through the ground can remain specifically infected through any continued interval even if the materials were negligible, which of course cannot ordinarily be the fact.

Much attention has been given to the elimination of sources of pollution in the neighborhood of ground-water collecting works, and

surface water has been carefully excluded by proper construction methods at all plants installed during the emergency.

Disinfection of water supplies. No great reliance was placed on the ability of filters to produce more than an aesthetically satisfactory water; consequently, disinfection by chlorination was instituted for every surface water supply as well as for every ground water of doubtful quality. A wealth of data is available in the army records as well as from civil experience to prove the necessity for this precaution. Table 5 has been prepared to present the situation as expressed by army experience. It contains a summary of a part of the data for Camp Meade, which is supplied with a coagulated, settled and filtered water from Little Patuxent River, a stream heavily polluted with sewage only a few miles above the camp water intake.

TABLE 5A

Record of bacterial efficiency, water purification plant, Camp Meade, Md.

Source of supply, Little Patuxent River; nominal capacity of filters, 3,000,000 gallons daily, rapid sand gravity type; capacity of coagulation and settling tanks, 400,000 gallons; coagulant used, Al_2SO_4.

1918 to 1919	TOTAL COUNT, AGAR, 37°, PER CUBIC CENTIMETER			BACTERIAL REMOVAL BY FILTERS	PRESUMPTIVE TESTS FOR B COLI				B. COLI CONFIRMED, CHLORINATED 10 CC.	AVERAGE CHLORINE DOSE
					Filtered water		Chlorinated			
	Raw	Filtered	Chlorinated		Number	Plus in 1 cc.	Number	Plus in 10 cc.		
				per cent		*per cent*		*per cent*		*p.p.m.*
February	970	64.0		93.4						
March	890	10.0	3.0	98.9						0.59
April	910	30.0	6.0	96.7	54	16.0				0.55
May	4800	78.0	5.0	98.4	61	26.0				0.55
June	760	42.0	4.0	94.5	46	24.0				0.58
July	700	44.0	2.0	93.7	79	6.0				0.55
August	2300	207.0	16.0	91.0	137	16.0				1.22
September	1080	31.0	5.0	97.1	360	37.5	360	16.5	0	1.28
October	318	24.0	3.0	92.0	370	10.8	116	0.8	0	1.09
November	434	82.0	8.0	81.0	372	17.4	144	9.7	0	1.07
December	1500	15.0	1.0	96.3	712	14.6	240	7.8	0	1.57
January	422	8.0	0.37	97.2	612	7.3	135	2.9	0	1.22
February	250	2.4	0.2	97.1	352	6.8	120	0.0	0	1.20
March	615	9.5	0.64	98.5	448	5.5	145	3.3	0	1.26
April	700	21.0	0.78	97.0	369	26.5	120	5.8	0	1.01
May	381	9.4	0.45	90.2	175	39.0	125	1.6	0	1.01

TABLE 5B

Record of bacterial efficiency, water purification plant, Fort Worth, Texas, supplying Camp Bowie

1918 TO 1919	TOTAL COUNT, NUTRIENT AGAR, 37.5°			BACTERIAL REMOVAL BY FILTERS	PRESUMPTIVE TESTS FOR B. COLI				B. COLI CONFIRMED, CHLORINATED, 10 CC.	AVERAGE CHLORINE DOSE
					Filtered water		Chlorinated			
	Raw	Filtered	Chlorinated		Number	Positive in 1 cc.	Number	Positive 10 cc.		
				per cent		*per cent*		*per cent*		*p.p.m.*
September	420	52	1500	80.7	30	0	30	0	0	1.05
October	307	57	565	81.4	29	20.7	29	0	0	0.77
November	1297	273	68	78.9	29	10.4	29	0	0	0.56
December	1096	280	52	95.3	31	3.3	31	0	0	0.60
1919										
January	1986	475	53	76.8	28	0	28	0	0	1.12
February	866	201	54	76.8	28	3.5	28	0	0	1.02
March	241	58	30	75.9	31	0	31	0	0	0.55
April	979	310	58	68.3	30	0	30	0	0	0.38
May	419	186	46		31	0	31	0	0	0.51

The filters have been very efficient in the removal of turbidity, since the water supplied the camp has practically always been clear and attractive, although very high turbidities are occasionally encountered in the raw water, but their efficiency has not been so satisfactory in the removal of bacteria. While the total number of bacteria (agar, 37°, twenty-four hours) present in the filtered water is well within the limits of the Treasury Department standard, which has been adopted as the army standard, B. coli was present with great frequency in 1 cc. samples, both in the presumptive and confirmed (not shown in table) tests. In the chlorinated water the total count was greatly reduced and B. coli was seldom found in 10 cc. by the presumptive test and the few thus found were practically never confirmed on Endo's medium.

Experience with waters only slightly polluted, in which B. coli appears occasionally in 1 cc., indicate the same inability of filters to produce a water which will regularly pass the standard even with most careful operation. This subject is not discussed with a desire to minimize the importance of filters, because their importance in water purification can hardly be assailed, but for the purpose of emphasizing the necessity of the final treatment, disinfection.

TABLE 6

Showing source, ownership and treatment of water supply of 48 large camps and cantonments

CAMP	NEAR	SOURCE OF SUPPLY	OWNERSHIP	FILTRATION*	CHLORINATION
Beauregard	Alexandria, La.	Wells	Government	None	Intermittent
Benning‡	Columbus, Ga.	Upatoi Creek	Government	Yes	Constant
Bowie	Fort Worth, Tex.	Trinity River	Municipal	Yes	Constant
Bragg‡	Fayetteville, N. C.	Little River	Government	Yes	Constant
Charleston P. T.	Charleston, S. C.	Goose Creek	Municipal	Yes	Constant
Cody	Deming, N. M.	Wells	Municipal and Government	No	Emergency
Custer	Battle Creek, Mich.	Wells	Government	No	Emergency
Devens	Ayer, Mass.	Wells	Government	No	Constant
Dix	Wrightstown, N. J.	Rancocas Creek	Government	No	Constant
Dodge	Des Moines, Ia.	Wells	Government	No	Constant
Doniphan	Fort Sill, Okla.	Lake Lawtonka	Municipal	Under construction	Constant
Edgewood	Edgewood, Md.	Winter's Run	Government	Yes	Constant
Eustis	Lee Hall, Va.	Wells	Government	No	Emergency
Forrest	Chickamauga Park	Tennessee River Chattanooga City Supply	Private Co.	Yes	Constant
Fremont	Palo Alto, Cal.	Galleries	Municipal	No	None †
Funston	Fort Riley, Kans.	Wells	Government	No	Constant
Gordon	Atlanta, Ga.	Chattahoochie River	Municipal	Yes	Constant
Grant	Rockford, Ill.	Wells	Government	No	Emergency
Greenleaf	Chickamauga Park	See Forrest	Municipal	Yes	Constant
Greene	Charlotte, S. C.	Catawba River	Municipal	Yes	Constant
Hancock	Augusta, Ga.	Savannah River	Municipal	Yes	Constant
Humphreys	Accotink, Va.	Accotink Creek	Government	Yes	Constant
Jackson	Columbia, S. C.	Congaree River	Municipal	Yes	Constant

Johnson	Jacksonville, Fla.	Wells	Government	No	None
Kearney	San Diego, Cal.	Morena and Otay Reservoir	Municipal	Yes	Constant
Knox‡	Stithton, Ky.	Mill Creek	Government	Yes	Constant
Las Casas	San Juan, P. R.	Rio Peidras	Municipal	Yes	Constant
Lee	Petersburg, Va.	Appomattox River	Municipal	Yes	Constant
Lewis	American Lake, Wash.	Springs	Government	No	Intermittent
Logan	Houston, Tex.	Wells	Municipal and Government	No	Intermittent
McArthur	Waco, Tex.	Brazos River	Municipal	Yes	Constant
McClellan	Anniston, Ala.	Springs	Municipal	No	Constant
Meade	Admiral Jc., Md.	Patuxent River	Government	Yes	Constant
Merritt	Tenafly, N. J.	Hackensack River	Private Co.	Yes	Constant
Mills	Garden City, L. I.	Wells	Government	No	None
Newport News	Port of Embarkation, Va.	Warwick River	Private Co.	Yes	Constant
Norfolk	Port Terminal, Va.	Impounding Res.	Municipal	Yes	Constant
Pike	Little Rock, Ark.	Arkansas River	Private Co.	Yes	Constant
Sevier	Greenville, S. C.	Little Mountain Creek	Municipal	No	Constant
Shelby	Hattiesburg, Miss.	Wells	Government	No	None
Sheridan	Montgomery, Ala.	Wells	Municipal	No	None
Sherman	Chillicothe, Ohio	Wells	Government	No	Constant
Stanley	San Antonio, Tex.	Wells	Government	No	Constant
Travis	San Antonio, Tex.	Wells	Private Co.	No	None
Wadsworth	Spartanburg, S C..	Lawson's Fork	Municipal	Yes	Constant
Wheeler	Macon, Ga.	Ocmulgee River	Municipal	Yes	Constant
Upton	Yaphank. L. I.	Wells	Government	No	None

* In all cases filtration is preceded by coagulation.
† Part of supply from surface source is chlorinated.
‡ Camp under construction June 1, 1919.

The use of liquid chlorine for the disinfection of the water supplies at the camps was almost universal. Table 6 contains a list, as an example, of the 48 large camps, with a statement showing whether or not disinfection was employed regularly, intermittently or on one or more occasions of emergency. In the smaller camps a larger percentage of ground water supplies was utilized. Disinfection was employed at 11 out of 28 establishments of the Aviation Section, utilizing ground water sources developed by the government, at two out of eight ground water sources developed by nearby municipalities and at all surface water supplies (two developed by government, fifteen by municipalities) except one field, supplied from the City of Washington.

B. coli has been frequently found in several of the ground water supplies where extended investigations by competent persons have shown that dangerous contamination was improbable, and these supplies were intermittently chlorinated. In practically all camps, the presence of B. coli in the water supply was demonstrated immediately after the completion of the systems, due probably to the entrance of dirt and foreign matter into the wells and distribution systems during construction. In one camp a sharp outbreak of diarrhoea occurred in February, 1919, among men who were quartered in one section of the camp in which new distributing pipes were being laid. The water at its source and throughout the other sections of the camp was of excellent quality, while that in the area in question was highly polluted. Careful investigations proved beyond a doubt that the infection was introduced into the distribution system during the laying of the new pipes. In some camps, where a large proportion of the distribution systems consists of wood pipe, there have been many blowouts and repairs, thus causing a more or less frequent recurrence of conditions prejudicial to the quality of the water supply. Careful chlorination has been necessary, and in most cases accomplished, in instances of this type.

The application of chlorine under the many and varied conditions encountered has indicated that the equipment for this purpose is not yet ideal, and it is manifest that careful and trained operators are necessary in order to accomplish disinfection successfully. Doses ordinarily ranged from 0.25 to 1.0 part per million but in two camps regular doses of from 1.25 to 1.6 parts per million are used, with maximum doses as high as 3 parts per million. An effort has been made to maintain duplicate equipment and spare parts at each installation

and occasional failures of machines to function properly have justified this policy.

Laboratory control and determination of quality. Laboratory facilities in surprisingly large array have been available in connection with the sanitation of all military establishments of the United States, both at home and abroad. The important place of the laboratory in military medicine and hygiene has been fully recognized and demonstrated during this war. Indeed it may be said that the development and utilization of the laboratory make one of the most striking and significant forward steps in the control of infectious disease and the conduct of practical sanitation.

At least 104 laboratories have been developed and maintained in continental United States by the Medical Department of the army for such length of time during the emergency as has been necessary. This number is comprised about as follows:

Departmental laboratories, permanent. (Eastern and Northeastern,* Southeastern, Southern, Central and Western)	5
Recruit Depot laboratories, permanent. (Fort Slocum, Fort McDowell, Columbus Barracks, Jefferson Barracks, Vancouver Barracks)	5
Port of Embarkation laboratories	2
Base Hospital laboratories (approximately)	48
General Hospital laboratories (approximately)	43
Total	104

* At Army Medical School, Washington, D. C.

In addition to those just enumerated, there are two departmental laboratories, one in Hawaii and one in the Philippine Islands.

In Europe a very large number of general and special laboratories was developed and maintained to serve the American Expeditionary Forces. Fully one-half of the entire laboratory personnel of the army saw service in Europe and the number of general laboratories abroad was fully equal to that at home. In addition, a considerable number of laboratories for water supply control work alone was provided. There were three permanent or fixed large laboratories in Engineer Corps buildings and six other fixed laboratories in Medical Department buildings. Furthermore there were ten mobile laboratories, four of which were mounted on trucks and six were contained in specially devised chests. These laboratories were all operated by

Sanitary Corps personnel under the direction of the Engineer Corps. In the 40, more or less, divisional laboratories maintained and operated by the Medical Department, Sanitary Corps officers were stationed in charge of water supply.

Practically all of the laboratories of the Medical Department have been fully equipped for making bacteriological examinations of water, milk, sewage, etc., according to the standard methods of the American Public Health Association, and those of the Army, both virtually identical. A few laboratories have been equipped to perform chemical examinations of water, milk, sewage, etc., both mineral analyses and sanitary, so-called. Of the fourteen permanent army laboratories, five at least are equipped for this chemical work, and in general, for the conduct of investigational work of considerable scope. Certain base and general hospital laboratories have been similarly equipped. A notable example of such provision for the investigation of sanitary engineering problems and the conduct of the practical sanitation of an army post is the sanitary section of the base hospital laboratory at Camp Meade, Md. This has been equipped to perform chemical and bacteriological work in connection with the examination and analysis of water, milk, foodstuffs, sewage, grease, various waste products and the materials and supplies employed in the control and operation of water purification and sewage treatment works. It is operated under the immediate supervision of Sanitary Corps officers trained and experienced along this line of work. In this laboratory, during the year or more of its existence, hundreds of samples of water, sewage, milk, ice cream, soft drinks and miscellaneous products and materials have been examined chemically and thousands of samples have been examined bacteriologically.

Laboratory methods in the army have been fully standardized and a very complete manual of procedure has been published. It is known as "Medical War Manual No. 6, Laboratory Methods of the United States Army." The first edition is dated 1918. A second edition, thoroughly revised, was published early in the current year. This manual is a highly creditable enterprise for which the Division of Infectious Diseases and Laboratories, by which it was compiled, deserves the highest commendation.

A form for recording and reporting the results of the bacteriological examination of individual water samples has been recently devised by the division for use by all army laboratories. As a matter of possible interest, this form is presented herewith.

Bacteriological examination of water

From.....
.....Laboratory
.....1919
To.....
.....
.....
.....
Sample from.....
Date collected.....1919
No.....Date examined.....1919
Appearance.....Sediment.....

AMOUNT OF WATER	LACTOSE BROTH, GAS PER CENT		ENDO		LACTOSE BROTH, GAS PER CENT		ORGANISMS
	Hours		Hours		Hours		
	24	48	24	48	24	48	
cc.							
0.1							
1							
10							
10							
10							
10							
10							

Cols. per cubic centimeter after 24 hours at 37°3. on..... agar.....
Rec. cols. per cubic centimeter after 24 hours at 37°C. on litmus lactose agar.....
Voges-Proskauer.....
Methyl red.....
Remarks:.....
.....
.....

NOTE: One copy of every report of examination of water will be forwarded to the Surgeon General.

All analytical work will be done in accordance with the latest Standard Methods for Examination of Water and Sewage of the American Public Health Association. D-274

The Maintenance and Repair Branch of the Construction Division, which has been charged with the operation of water and sewerage works in all army camps, has developed two or three laboratories in

which chemical and bacteriological examinations of water, sewage and other materials have been made. These utilities laboratories have been installed for the immediate purpose of controlling water filtration operations, but in some instances, as at Camp Meade, they have been extended in scope to permit of investigations of sewage treatment and other problems.

In connection with its extra-cantonment activities, the United Stages Public Health Service developed some 40 bacteriological laboratories, all of which were equipped for water examination work. These laboratories have contributed generously in all problems relating to the safety of drinking water supplies, not alone in extra-cantonment zones but within military reservations as well.

Red Cross laboratories have also generously extended their aid in the practical sanitation of army camps, including the determination of the quality of water supplies and the production of the hygienic safety thereof.

Health of posts as related to the water supply. It is of course now well recognized that the so-called water-borne diseases (typhoid fever, cholera, dysentery, certain diarrhoeas, etc.) are not conveyed by water alone. Milk and other foods, flies and perhaps certain other insects, and possibly still other factors less significant are, together with water, responsible for this group of diseases. The program of army hygiene and sanitation has been laid out and so conducted as to eliminate, to the fullest possible extent, all of these factors.

In general, this program of control of disease has comprised two great methods of attack: (a) the method of direct control by the immunization of the individual; (b) the method of mass control by the control of the environment.

Practically every soldier in the army and as far as possible the civilian employees at army posts have been systematically vaccinated against typhoid fever. Cholera has been so completely controlled for many years in this country by quarantine and other methods that it has not been considered necessary to vaccinate against this disease. It is reassuring, however, to realize that such a means of control has been developed and is available whenever necessary. A successful vaccine to protect the individual against dysentery (in the causation of which several strains of bacteria and an amoeba are concerned) has not yet been developed.

It has been the object of this discussion to outline the control of the environment of the soldier, as related to the provision of a safe

water supply and the precautions which have been and are being taken to insure supplies of satisfactory quality. The control of flies and other insects, the provision of clean and suitable foods, the attention which has been given to other important features of environmental control would indeed make an interesting story, but do not fall within the scope of this paper.

Experience in the army and elsewhere seems to show that vaccination against typhoid fever cannot certainly protect all individuals against massive infections or doses of virulent bacteria, especially when such infective material is suddenly encountered, as with a recently and grossly contaminated water or food supply. The conclusion which must be drawn from this fact is that sanitation cannot concern itself with the control of one factor only in the spread and conveyance of diseases or any particular disease, but every known avenue of infection must be blocked, every known means of control must be utilized. This principle has been most consistently applied in army sanitation, with results which have been nothing short of epochal.

During the period September, 1917–April, 1919, with an average strength of more than 2,000,000 men in the army in posts within the United States, there occurred but 213 deaths from typhoid fever and 42 deaths from dysentery. A large proportion of these cases was comprised of men passing through the incubation stage of these diseases at the time of their entrance into the military service. If conditions similar to those which prevailed during the Civil War had prevailed in our army during the recent period under consideration, the numbers of deaths from typhoid fever and dysentery in this group of soldiers would have been approximately 51,000 and 64,000 respectively. These values are about 240 and 300 times the corresponding figure for the recent period in question. Similarly, if the incidence of typhoid fever and for dysentery had been the same as for the Spanish American War the deaths would have numbered 68,000 and 6400 respectively, or 1620 and 150 times respectively, the actual deaths which did occur from these two diseases.

The following reference to the prevalence of typhoid fever in the American army and the general manner of its control has been abstracted from the report of the Surgeon General, U. S. Army, 1918:

> Since 1911, the Surgeon General's reports have each year represented an increasing amount of convincing evidence of the value to the army of com-

pulsory antityphoid inoculation. In 1917 this method of protection was of course tested on a much greater scale than ever before, but the results have justified the previous conclusions as to its value. Substantial protection has been secured not only against typhoid, but also against paratyphoid A and B by use of the triple typhoid vaccine adopted soon after the declaration of war.

It will be noted in the statistical part of this report that during the year 1917 there were 297 cases of typhoid; 13 cases of paratyphoid A; 7 cases of paratyphoid B. A large proportion of the cases occurring in this country were in men who were in the incubation period of the disease on their entrance into the military service. The reports of the cases which occurred in France indicate that almost all the patients had escaped receiving the typhoid prophylactic.

During the Spanish War of 1898 the admission rate for typhoid was 141 per 1000 and the death rate 14 per 1000. If this experience had been repeated in this war, for each 1,000,000 men there would be 140,000 cases of typhoid and 14,000 deaths. It can not be claimed that all of our protection from such a calamity is due to vaccination, as sanitation had much effect, but enough cases are occurring in spite of all precautions to show that there is constant danger of infection and constant need of protection by vaccination.

Recent experiments conducted at the Army Medical School have resulted in the perfecting of an oil vaccine modeled after the French vaccine, by which a complete immunization can be given in one dose. This is a distinct practical advance as an administrative measure, as it saves time and labor. A full report of the work of the Army Medical School is presented elsewhere.

Examination of all food carriers has been made for carriers of the typhoid group of organisms, and carriers found have been excluded from food handling. Where possible these carriers have been sent to the Walter Reed General Hospital for study and treatment. One cook whose urine was practically a pure culture of typhoid bacilli was found to have a pyonephrosis on one side. His kidney was removed and he made a complete recovery as a carrier. Two gall-bladder typhoid carriers have been operated on for cure by removal of the gall bladder and are still under observation.

* * * * * *

The great reductions in disease are those brought about by improved sanitation. Diarrhea and dysentery are reduced from 244,000 to 11,000, due to treatment of feces and fighting the fly. Typhoid fever is reduced from 10,000 to 225 by keeping down the fly and especially by protective inoculation; typhoid, the former great scourge of armies, has become as negligible as small pox. Malaria has been reduced from 167,000 to less than 2000 due to elimination of mosquito breeding areas.

A most interesting bulletin, designated Circular No. 69 and entitled "Typhoid-Paratyphoid Fevers" was issued under date of February 17, 1919, by the Chief Surgeon, American Expeditionary Forces. From this publication the following extracts are quoted as a matter of interest, and as showing the effect of massive doses of infectious material:

II. Summary of typhoid-paratyphoid incidence in the American expeditionary forces. In order that all medical officers in the American Expeditionary Forces may have a somewhat comprehensive view of the occurrence of these evers in the American Expeditionary Forces the following brief review is presented.

(a) From June 1, 1917, to June 1, 1918, but few cases occurred. The rate was well within the limits to be expected, in view of the sanitary conditions under which the troops were of necessity living. The cases were sporadic and only occasionally did secondary cases develop.

(b) In July, 1918, a replacement unit consisting of 248 men from Camp Cody, N. M., reached England with typhoid prevailing extensively; 98 men, or 39.5 per cent, had typhoid and the case death rate was 8.42 per cent. It was evident from the investigation that the men were exposed to infection through contaminated drinking water while en route to the port of embarkation in the United States. The unit had been vaccinated a few months prior to the occurrence of the epidemic. Most of the patients presented the typical clinical features of typhoid. The percentage of positive bacteriological findings from the blood, feces and urine was low, as no laboratory work could be done until late in the course of the disease.

(c) In August, 1918, a small but severe epidemic occurred in a detachment of engineer troops stationed at Bazoilles. In this unit fifteen cases of typhoid occurred with a death rate approximating 10 per cent. Typhoid was endemic in the civil population and the epidemic was very definitely traced to a cook in the mess of this engineer detachment, who remained on duty as cook for five days after the onset of the symptoms. The epidemic was recognized in its early stages and in all patients the disease was confirmed bacteriologically by positive cultures from the blood and feces.

(d) During the Chateau Thierry offensive diarrhoeal diseases were very prevalent in the troops engaged (approximately 75 per cent). It was demonstrated bacteriologically in this area, that the prevailing intestinal diseases were simple diarrhoea, bacillary dysentery, typhoid and paratyphoid A and B. The sick and wounded from this sector were evacuated to base hospitals in various parts of France. Very soon thereafter this office began to receive reports of cases of typhoid, paratyphoid and bacillary dysentery from base hospitals. In practically all instances the patients had been evacuated from the Chateau Thierry sector. The high incidence of intestinal diseases in this sector was due to the entire disregard of the rules of sanitation. "Military necessity" and the impossibility of supplying auxiliary labor troops, at that time prevented immediate police of the battlefields. In some of the cases involved in this series, the diagnosis of dysentery or typhoid was made by the pathologist at autopsy. The percentage of positive bacteriological findings was low as the correct diagnosis, if made, was not usually arrived at until late in the course of the disease.

(e) Both dysentery and typhoid-paratyphoid fevers were demonstrated to have prevailed to some extent in our troops after the St. Mihiel offensive, but the epidemics of influenza and pneumonia prevailing at that time overshadowed all other medical admissions.

(f) Following the offensive in the Argonne sector, typhoid and paratyphoid began to be reported from practically all divisions engaged in that offensive.

It is quite evident that the initial cases were due, in a large part, to drinking infected water. The initial cases, however, in large part were not, in most instances, promptly diagnosed and secondary cases from contact began to occur. In some divisions either the initial exposure was not great, the organizations were under good discipline, or the medical officers had a proper conception of their duties and responsibilities and but few cases occurred. In other instances the contrary was true and many cases have occurred. As examples of the two extremes may be cited the — Division in which five cases occurred between October 1, 1918, and February 1, 1919, and the — Division in which 115 cases occurred in the same period.

More than 300 cases of typhoid-paratyphoid may be attributed to the Argonne offensive. Eight hundred and seventy-four typhoids and paratyphoids have been reported in the American Expeditionary Forces since October 1, 1918. The percentage of confirmatory laboratory diagnoses has been low on account of the fact that the clinicians frequently failed to suspect the disease in its early stages.

(g) A small but severe epidemic occurred in the Joinville concentration area in December and January. In a group of Medical Department units (evacuation and mobile hospitals and sanitary trains) concentrated there 75 cases occurred with a case death rate of approximately 20 per cent. The cases were suspected in the early stages of the disease and the percentage of positive findings by culture of urine or feces has been greater than 75 per cent. The cause of this epidemic has not been completely analyzed as yet, but there is but little question that it was due to the use of infected drinking water.

VII. Prevention and control of typhoid and paratyphoid fevers. Vaccination is a partial protection only and must be re-enforced by sanitary measures.

* * * * * *

Remember: That all water in France is regarded as contaminated unless it is under constant supervision of water supply personnel. See that G. O. 131, G.H.Q., 1918, is carried out. Don't give orders only; personally assure yourself that chlorination is properly carried out. The responsibility ultimately falls upon those charged with sanitary control and not upon the enlisted man who mixes the hypochlorites of lime with the water. Study the means of prevention of drinking at unauthorized sources. The best way to do this is to see that an adequate supply of supervised water is conveniently available, wherever men work or live. Other means are the marking of water points; the removal of faucets; the placing of guards, and last but most important, the education of the men.

The following extracts from two monthly reports of an officer on duty as a camp sanitary engineer will serve to call attention to the necessity for eternal vigilance in the operation of water purification plants (especially where the raw water is grossly and immediately contaminated with untreated sewage) and the very real danger which must lie in any short circuiting of treatment.

During the period, ... 1918, on at least five separate occasions, considerable volumes of water passed from the purification plant without receiving any dose of chlorine whatever, and on at least one other occasion the dosage was entirely inadequate for disinfection. In all, during the days in question, it appears that fully 750,000 gallons of water passed from the plant either without any chlorine treatment whatsoever or with entirely insufficient dosage. No investigation has yet been made of the continuity of chlorine treatment prior to .....

* * * * * *

The filters cannot be relied upon for effective disinfection due to the coarseness of the sand, to the seriously polluted water which requires treatment, to the heavy turbidity which appears at times of storm and to the inadequacy of the coagulating and subsiding tanks at such times. In fact, in recent years, dependence has rarely been placed solely upon filters of any sort, for a desirable and perhaps necessary degree of bacterial removal.

Under date of ..... 1918, ..., M. C. reported the positive presence of B. dysenteriae (Shiga type) in a sample of laboratory tap water, taken at the Base Hospital on ..... The number of colonies developing on agar plates incubated for 24 hours at 37°C. was 5 per cubic centimeter. Five fermentation tubes, each receiving 10 cc. of the sample, showed no gas in 24 hours, but three showed gas in 48 hours. One tube inoculated with 1 cc. of the sample failed to show gas in either 24 or 48 hours. A memorandum on the report of the samples reads as follows: "Endo colonies transplanted to Russell's medium—no change in medium. Agglutination occurred with one of the transplants with Dysentery serum of the Shiga type."

On the same date, B. dysenteriae were reported in a sample of chlorinated water taken from a tap on one of the pumps at the high service pumping station on ..... The number of colonies developing on agar plates incubated for 24 hours at 37°C. was 18 per cubic centimeter. Five fermentation tubes each receiving 10 cc. of the sample showed no gas in 24 hours and in one tube only was gas present after 48 hours of incubation. The tube inoculated with 1 cc. of the sample failed to show gas in either 24 or 48 hours. A memorandum on the report of this sample was as follows: "Endo-negative colonies on Russell's medium—no change. Agglutination with dysentery serum of Shiga type. One tube agglutinates with the Flexner type."

It is significant that cases of dysentery appeared in ..... on .... 1919. During ..... there occurred a considerable number of cases of dysentery, both recognized and reported as such and unrecognized and unreported. The history of this disease is fully set forth in the monthly report for ..... 1918 of ....., camp epidemiologist.

* * * * * *

With the improved operation of the purification plant as respects chlorination, the rather serious epidemic of dysentery and diarrhoea occurring in ..... was promptly checked and so effectively that only one case of dysentery was reported during ..... In ..... there were reported 11 cases of dysentery and fully 100 cases of diarrhoea which gave ground for suspecting the existence of mild or moderate bacillary dysentery. There

were many cases of unreported diarrhoeas throughout the camp (See .... report of ....., camp epidemiologist).

With respect to the matter, ..., in his ..... report, says: "A single case of dysentery of undetermined type occurred, in contrast with the record of dysentery for ....., and abundantly justified our views of the causation of the ..... cases (infected drinking water due to a breakdown in the chlorination plant). The water reports during ..... have been excellent and the absence of diarrhoeal diseases has likewise been noteworthy."

Some lessons taught by recent army experience. Holding in review the various circumstances and conditions which have been obtained with respect to the control of the quality of water supplied to our army camps, especially in the United States, it would appear to the authors that the following general conclusions, which ought to govern future practice and procedure, may properly be drawn:

1. The variability in bacteriological quality which has been observed with respect to a considerable number of ground waters supplies has shown that frequent examinations should be made of samples collected from different points in the water supply system. This should be the case, regardless of the cause of the variation in quality. This variation may be due to differences in intensity of contamination of the water itself or to disturbances to the distributing pipe system on account of breaks or extensions, or to disturbances caused by repairs of well casings, etc.

2. Unless a ground water supply can show consistently good quality with consistently thorough laboratory examinations throughout a considerable period of time, it should be regarded with suspicion and treated accordingly.

3. Except under extraordinary circumstances, involving exceedingly successful design and construction and the most vigilant and intelligent operation, the effluents of rapid sand filter plants treating waters polluted with fecal wastes to a significant degree cannot be considered to be consistently safe and should receive further systematic treatment, as by adequate chlorination.

4. An extraordinary inefficiency and lack of intelligence is too frequently to be noted with respect to the operation of rapid sand filter plants, especially those of municipalities, and of these, naturally, the smaller communities in which the authorities do not recognize the value of expert services and the relative economy of the highest skill.

5. All water supplies, from whatever source, should be regarded as potentially unsafe and should receive adequate disinfection unless or until, through a sufficient period, their satisfactory quality without disinfection is consistently demonstrable through comprehensive laboratory examinations.

6. All chemical dosing apparatus of whatever kind must be considered at the present time as innately insubstantial and liable to breakdown. Such apparatus, if proposed or required for continuous service, must therefore be invariably installed in duplicate and in some cases in multiple units and its operation should be under constant observation.

7. The required dosage of disinfectant, whether that disinfectant be liquid chlorine employed at a large purification plant or calcium hypochlorite employed in a Lyster bag, must be determined and that dosage should be adjusted, at least approximately, to variations in character and composition of the supply undergoing treatment.

8. In non-immunized communities all water supplies and in thoroughly vaccinated communities all water supplies which are subject to even moderate contamination must be regarded as having utmost hygienic significance. There must be at least one competent agency charged with the immediate duty and responsibility of guaranteeing a safe, wholesome and aesthetically satisfactory water supply to every community. In the army, as shown herein before, there are several agencies more or less independently charged with this duty. The principle has found objection on the part of some on the ground that "what is everybody's business is no one's business." Because of the direct personal responsibility which the army enjoins, this objection cannot apply as it might in civil affairs, and there have been many experiences which have demonstrated the practical value of this scheme of organization. It is not a case of divided but of coördinated responsibility. Coördinated responsibility should be made a shibboleth in civil as well as military establishments.

MOTOR-TRUCK-MOUNTED WATER PURIFICATION UNITS[1]

By Wm. J. Orchard

The world war brought forth many novel developments in every line of endeavor, and although the water supply field was but one of many, it is pleasing to present before this convention of water works men, a discussion of the units developed and manufactured in this country by members of this Association to be operated in France and elsewhere by other members engaged in delivering safe water supplies to our military forces. The portable motor-truck-mounted water purification units about to be described present nothing new in the fundamental principles of water purification of, but show the applicability of the principles used in stationary domestic plants to portable plants for military use.

In 1914, the necessity for a specially organized water service was not recognized by any of the allied forces, water supply functions being the duty of engineering troops. The purity of the water was determined by the medical department. The water supply conditions presented in France and in Belgium and the problems of water supply met in trench warfare were entirely different from problems presented in previous wars. The soils of Northern France and Belgium were for the most part highly cultivated, fertilized for scores of years with night soil and other refuse, so that water supplies normally obtained in the battle area were highly polluted. Then, too, the German forces in passing over the country indescribably polluted all water left behind when retreating, making special measures necessary for purification. It is reliably reported that the 1915 Champaign campaign of the French army broke down largely due to the inadequacy of water supply arrangements, and at the close of this campaign, the French war office organized a special water service for the second French army, under the direction of Major Bunau-Varilla, well-known through his endeavors to construct the Panama Canal with French financial support.

[1] Presented at the Buffalo Convention, June 13, 1919.

The chlorination of all water supplies used for drinking and cooking purposes was required by the French military authorities. Calcium hypochlorite or sodium hypochlorite was applied in such quantities that 15 minutes after treatment there remained 0.2 part per million of residual chlorine. It should be pointed out that such excessive amounts of residual chlorine, greatly in excess of American practice, left objectionable tastes and odors in the treated water, so that the troops were apt to take the more palatable but dangerous untreated water from flowing streams, shell holes and the like, when possible.

The United States forces in entering the conflict, taking advantage of the lessons learned by the Allied forces, created a water supply regiment, the 26th Engineers, which was officered by experienced water works men, most of whom are members of the American Water Works Association. This regiment had charge of the water supply of the American forces, both in the advanced area and in the rear.

Early in the war, the need for portable water wagons for the purification of supplies was presented and bulky equipment with filters and devices for treating the water with hypochlorite were put forth. In 1916 the availability of apparatus of American manufacture to control liquid chlorine made possible the first efficient motor-truck-mounted water purification unit.

When this country entered the war, the Wallace & Tiernan Company believed that the experience it had gained through coöperation with its British house in construction of equipment for the British forces should be placed at the disposal of the military authorities. With this in view equipment based on the British unit, but modifying the typically English characteristics to introduce American methods and equipment, was constructed and tested under varying conditions at Maplewood, N. J. Water was taken from the West Branch of the Rahway River, a grossly polluted stream. This first unit was equipped with rotary pumps, which did not prove suitable, and subsequent units were equipped with gasoline-operated force pumps. Various member of this Association, who were officers in the Engineer Corps, or in the Sanitary Corps of the Army, offered helpful suggestions and contributions toward the development of this unit, which, when placed in operation, gave highly satisfactory results.

Separate water analytical laboratory trucks were contemplated, but it was ultimately concluded to modify the design to permit the

incorporation of suitable laboratory equipment. By building a separate room in front of the truck, using small cylindrical tanks for contact and storage chambers, and placing these tanks under the laboratory benches, a marked saving in the space required was effected.

The water is pumped through a 50-foot suction line of 2-inch steel woven suction hose, fitted with bronze check valve and strainer, by the gasoline-engine-operated pump located at the rear of the body. A very heavy dose of chlorine is applied in the pump suction, from a manually operated solution feed chlorinator, located on the rear wall of the laboratory room. When waters of low alkalinity are treated, soda ash is applied with the chlorine solution into the pump suction.

Passing through the pump, with a relief valve set to operate at 50-pounds pressure, the water is passed to a specially designed pressure filter, being treated with alum through a standard dash-pot arrangement en route.

From the filter, the water passes through a $1\frac{1}{2}$-inch water meter, thence through a diaphragm pressure-regulating valve to maintain constant back pressure on the chlorinator water supply line, thence through the storage and contact tanks located beneath the laboratory benches, to the point of discharge at the forward left-hand corner of the truck. Just at the point of discharge, the water is treated with sodium thiosulphate solution, regulated and controlled by a special dechlorinating equipment.

These units were designed to treat the grossly polluted and befouled waters that would have to be used and as a result of British practice and experience, high doses of chlorine were introduced into the raw water. The filters served to clarify the water, and at the trial tests, absolutely sterile water was obtained at the point of discharge.

It was thought necessary to make provision for removing the excessive residual chlorine that would be in the water after passing through the contact tanks, and a proportional pressure feeding thiosulphate dosing device was developed. It should be mentioned that provision for dechlorinating was made in accordance with the British experience, who used the process of dechlorination by the application of compressed sulphur dioxide gas in all of their portable units. On the British trucks the sulphur dioxide was controlled by a standard direct-feed manually controlled chlorinator, of American manufacture.

In the American truck, the chlorinator used was of the standard manually controlled solution feed type. Control valves for the soda ash and thiosulphate solutions were in the rear of the laboratory below the chlorinator, so that all chemical application should be centrally controlled by the laboratory operator.

The first trucks were constructed with horizontal pumps, and it was found that special provision was required to eliminate excessive vibration in the laboratory. With this in view, special spring supports were developed. On the later trucks, a vertical force pump was used and this so eliminated the vibration as to obviate the necessity of special spring supports.

FIG. 1. WATER PURIFICATION TRUCK READY FOR THE ROAD

The development, construction and testing of the first lot of trucks, and the tests and recommendations of the Board of Inspecting Officers, representing the Office of the Chief of Engineers, the Engineering Depot, and the Sanitary Corps of the Army, resulted in many modifications of design and re-arrangement of equipment, but not in any change in the basic principles involved.

The value of these units became so apparent that increased facilities were required for their manufacture. An admirable factory in Camden, N. J., was obtained, and here in conjunction with the construction work, a school for Sanitary Corps men, members of the Water Tank Train, and officers who were to have charge of the trucks in operation, was conducted.

Figure 1 is a view of one of the trucks closed and ready for the road.

Figure 2 is a view of the rear of the completed truck, with the rear and side gates let down for operation. It shows the gasoline storage tank to the right of the pump, and provisions made for carrying and

FIG. 2. REAR VIEW OF A WATER PURIFICATION TRUCK READY FOR USE

chaining the suction hose. The filter, central control valve for operating the filter, electrical generator for lighting, soda ash solution tank, alum pot, dechlorinator, etc., and further details of the pumping room are shown in figure 3. In the upper right hand corner of this view is shown a tool box in which a complete set of pipe cutting and fitting tools is kept in addition to hand tools needed about a machine

shop, and beneath this tool case is the chemical bin, for storing alum, soda ash, and thiosulphate.

The laboratory arrangement in the latest trucks is shown in figures 4 and 5. The provision made for carrying chemical bottles is indicated, as is also the sink for washing glassware, and a hand air-pump for creating pressure in the storage tanks when the pumping equipment is not in operation. A 37° incubator for bacteriological samples, even for sterilizing glassware, and electric lighting equipment,

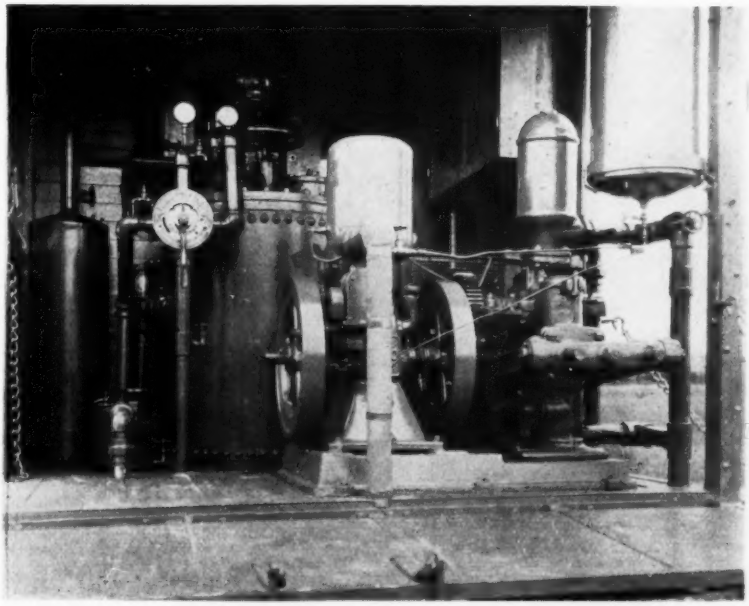


FIG. 3. CLOSE VIEW OF THE PUMPING ROOM

are illustrated, while in the rear of the laboratory is shown a standard solution feed chlorinator, and beneath it the thiosulphate and soda ash controls. On the bench beside the chlorinator is a pressure autoclave for sterilizing purposes.

The earlier trucks were mounted on 3½-ton truck chassis, but by far the largest number were mounted on 5-ton 17-foot wheel base chassis. Three horse-power gasoline engines were used, with 5 x 5-inch force pumps. The rated capacity of the unit was 1000 gallons per hour, although the actual delivery was nearer 1500 gallons.

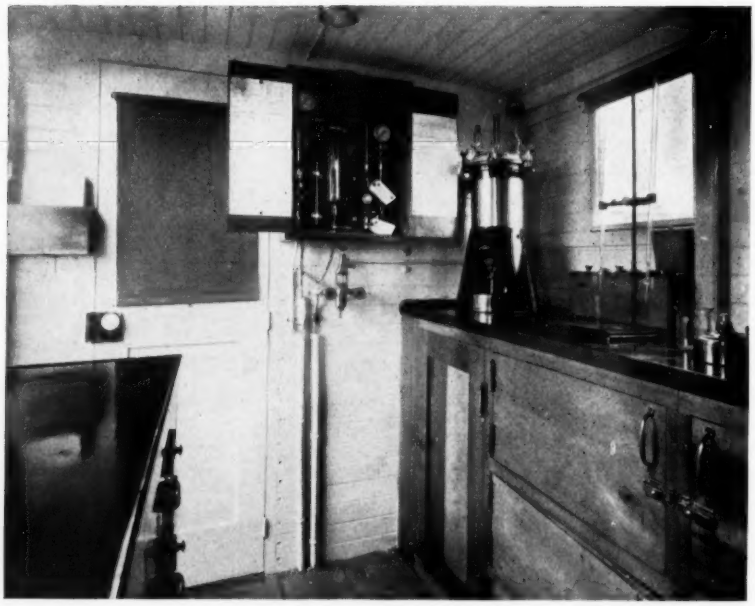


FIG. 4. VIEW IN THE LABORATORY ROOM

FIG. 5. VIEW IN THE LABORATORY ROOM

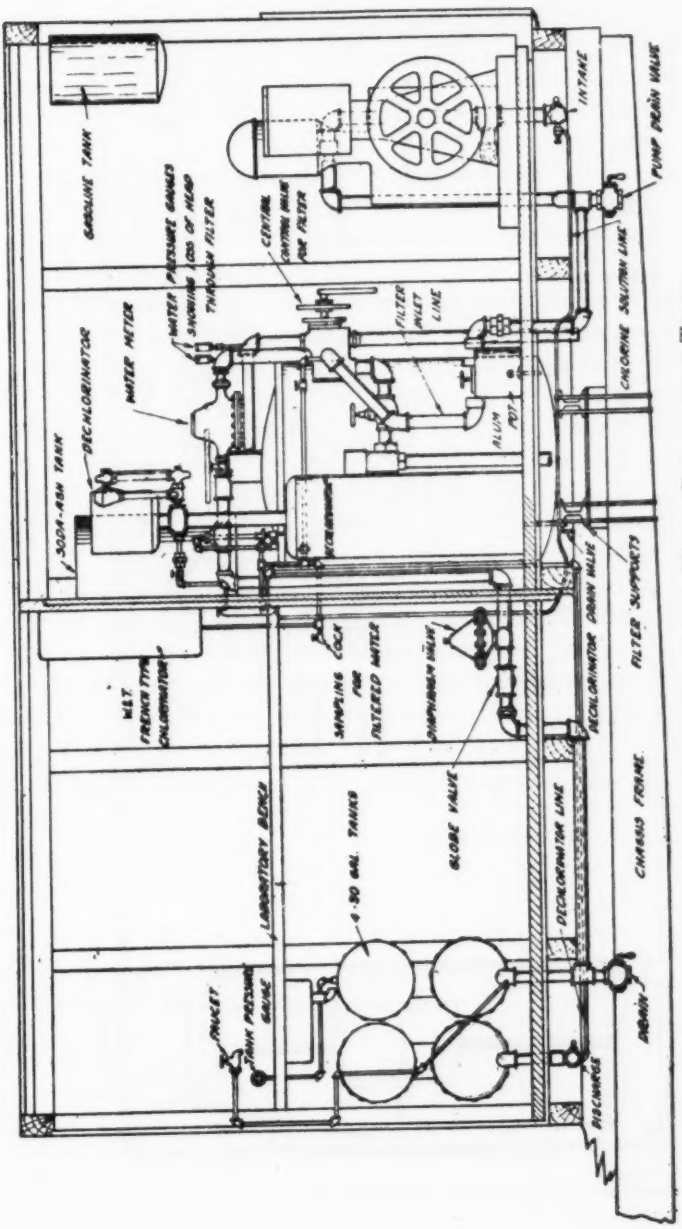


FIG. 6. SECTIONAL ELEVATION OF A WATER PURIFICATION TRUCK

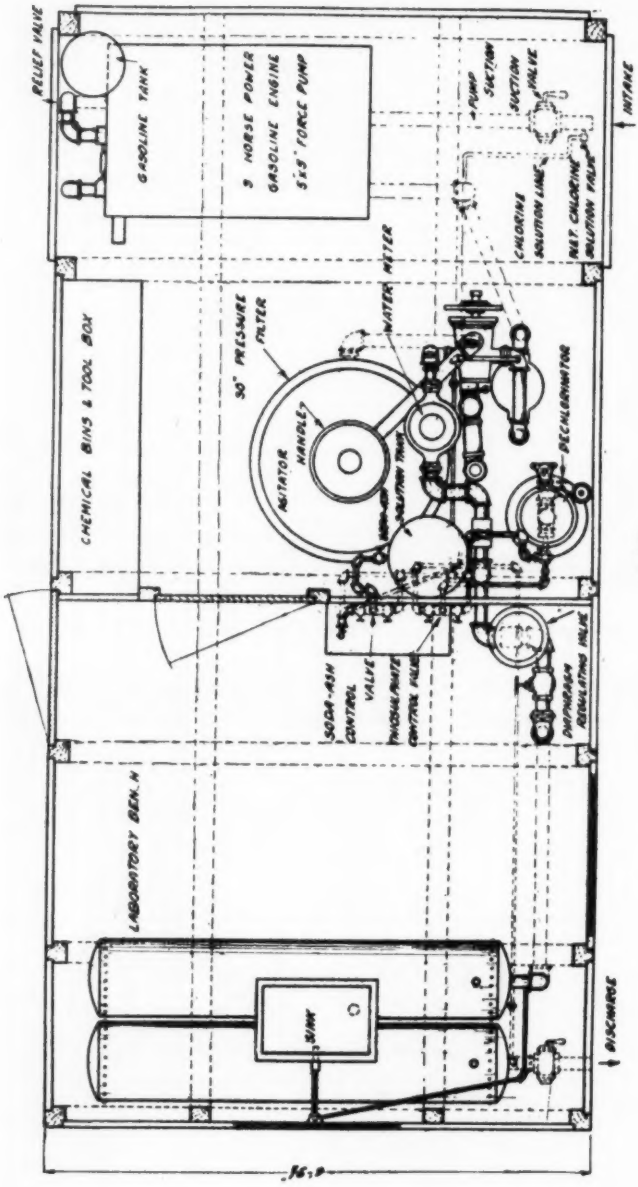


FIG. 7. PLAN OF A WATER PURIFICATION TRUCK

The support of the filter, which weighed 2400 pounds without the water, presented problems that required careful study. The final solution was to fasten 5-inch steel H-beams to the chassis frame by U bolts, bolting the filter to the H-beams by feet cast on the special filter base.

In addition to the equipment shown in figures 6 and 7, 1031 articles were carried. Still, much to the makers' dismay, when the trucks were first placed in operation, it was found that they had overlooked the very obvious item of a box of matches.

These units rendered valuable service under actual military operation in France. Some of them were injured by shell fire and some of the Sanitary Corps men wounded in operating the units near the firing line.

Acknowledgment must be made of appreciation of the coöperation extended by the Surgeon General's Office, the Sanitary Corps, the Office of the Chief of Engineers of the Army, the Engineer Depot and particularly to the following officers: Col. F. F. Longley, Lt. Col. Edward Bartow, Major H. McC. Yost, Captains Morris Scharff, Gerald W. Knight, W. F. Wells and J. J. Newmann, and Lieutenants A. H. Wagner, H. H. Scott and T. W. Smith. Without the suggestions and coöperation of M. F. Tiernan and C. F. Wallace these units could not have been constructed, and special thanks are due to two members of their staff, now in service in France, Capt. A. R. Murphy, who materially contributed to the development of the first unit in the tests at Maplewood, N. J., and Capt. R. V. Donnelly, who was in charge of their construction at Camden, N. J. Thanks are also due to the engineers of the Roberts Filter Manufacturing Company, for their especial coöperation.

COMMUNICATION FROM THE BUREAU OF STANDARDS ON STANDARD SCREEN SCALES

1. As you may recall, a tentative standard screen scale was adopted at a conference held at the Bureau of Standards in April, 1916. Although the development of that scale was interrupted by the war, a revision has now been prepared and submitted to the manufacturers of sieves and sieve cloth.

2. It is desired that this revised standard screen scale, a copy of which is enclosed, be ratified by those concerned, in order that it may be formally adopted. You are therefore requested to submit the following questions to such committees as may be concerned in the matter. Additional copies will be sent to your committees if you so desire, and will furnish us with proper addresses.

(a) Do you vote for the adoption of this revision?

(b) Will you recommend the use of this standard screen scale in the industry which you represent?

3. An early reply is desired as it is hoped to have this adopted at the earliest possible date. It is intended to take up the matter of standardization of dimensions of sieve frames, pans and covers very soon.

A STANDARD SCREEN SCALE FOR TESTING SIEVES

Paragraph 1. Since the adoption by the Bureau of Standards several years ago of specifications for standard 100 and 200-mesh sieves, frequent requests have been received that the Bureau test and certify other sieves than these. With a view to the adoption of a series of standard testing sieves which might be of use to all industries making fineness tests, the Bureau for several years has been studying the question of such a standard screen scale. Various scales that have been proposed have been considered, and information has been sought of representative firms in the various industries interested as to their requirements. Manufacturers of sieves have also been consulted as to the desirability of different screen scales and the practicability of their manufacture. As a result of

this study of the question, a conference was called at the Bureau of Standards April 20, 1916, of representatives of various committees of the American Society for Testing Materials, American Society of Civil Engineers, American Institute of Mining Engineers, American Foundrymen's Association, Mining and Metallurgical Association of America, American Water Works Association, American Institute of Metals and the American Spice Trade Association; also representatives of the Committee of Revision of the U. S. Pharmacopoeia, the U. S. Geological Survey, the U. S. Bureau of Mines, the U. S. Office of Public Roads and Rural Engineering (now Bureau of Public Roads), the U. S. Office of Grain Standardization and the U. S. Bureau of Standards; also representatives of a number of private firms engaged in industries in which sieves are used, such as the glass, the drug milling, the abrasive, the asphalt, the mining, the spice, the chemical, and the graphite industries; also representatives of the firms in this country manufacturing wire cloth and sieves. This conference, after considering the various screen scales either proposed or now in use, adopted a Standard Screen Scale, and recommended that it be adopted generally by scientific, technical, and engineering societies and committees, and by branches of National, State and Municipal Governments as a part of their specifications for materials and methods of test; also that it be used by private firms who have need of standard sieves. Specifications and descriptive matter of this Standard Screen Scale were mimeographed and issued in 1916.

Paragraph 2. Since then, certain desirable revisions have suggested themselves. These changes consist mainly in

(1) A revision of the openings to a mathematically exact geometric series, regardless of existing sieves.

(2) A revision of the wire diameters to give a regular increase in the ratio of wire diameter to opening throughout the series. This is the most radical of the changes suggested, and the proposed new wire diameters are based on a study of the behavior of existing sieves in some of which the wires are either too heavy or too light.

(3) A departure from any reference to mesh in either specifications or tolerances, the sieves being designated by arbitrary numbers.

(4) Limiting the tolerances for the present to percentage variations in the average sieve opening, the average wire diameter and the maximum sieve opening.

This revised screen scale as given in the attached table has been adopted by ———— and recommended by ————.

Paragraph 3. This screen scale is essentially metric. The sieve having an opening of 1 mm. is the basic one, and the sieves above and below this in the series are related to it by using the fourth root of 2, or 1.1892 as the ratio of the width of one opening to the next smaller opening. The series has been made large enough, it is hoped, to meet the needs of all industries. Some industries may have occasion to use all the sieves in a certain section of the series and none of the others, while in other industries it may be desirable to use only certain sieves selected from the whole range of the series. In making such selections it is recommended that this be done on some systematic plan, as for example, the selection of every other sieve or of every fourth one in the series. In the former case the ratios of each opening to the next smaller would be as $\sqrt{2}:1$, in the latter case 2:1.

Paragraph 4. Because of the wide range of openings in sieves now manufactured which are possible with a given number of meshes per unit length by the use of wires of different diameters, and the consequent confusion and uncertainty which arises in designating sieves by the number of meshes per unit length, it is recommended that all reference to mesh be avoided in the designation of the sieves, but that for convenience each sieve be given an abstract number such that the approximate place of the sieve in the series will be suggested thereby. The proper designation of a sieve is the size of the opening, supplemented by the wire diameter, but it is well recognized that few users of sieves will be able to carry the sizes of the various openings in mind without reference to a printed table, and also that few users of sieves will be concerned with the exact sizes of the openings in either metric or English units. All the user of sieves desires to know in general is that the sieves are "standard," that is, that they conform to established specifications, and therefore the only designation required is a simple one which will suggest the degree of fineness or coarseness of the material passing or retained upon any given sieve. Such a designation is an abstract number which is approximately the number of meshes per linear inch. The advantages of such a designation is readily apparent. Thus the basic sieve in the series, which has a 1 mm. opening, is given the number 18, which may be regarded simply as a fixed arbitrary number indicating that the sieve has approximately 18 meshes per inch. The fact that this sieve

has actually 17.2 meshes per inch or 7 meshes per centimeter is of no importance; the number 18 merely indicates to those who are familiar with the old sieves what order of separation this sieve would give in testing any graded material. It is urgently recommended that all users of sieves in the future designate these standard sieves in this way, and that the manufacturers mark and list the sieves in this manner, together with the size of the openings and the wire diameters in both millimeters and inches.

Paragraph 5. In the designation and certification of the sieves these arbitrary numbers and the metric units will be used by the Bureau of Standards. In the accompanying table, however, are also given the equivalents of these metric quantities in inches in order that the series may be more readily related to work previously done. It is, of course, immaterial whether units of the metric system, or of the customary system, or of any system, are used in the manufacture of the sieves, provided they are within the tolerances.

Paragraph 6. To meet the need for sieves of this series, at the present time, provision has been made in the specifications for the acceptance of sieves of slightly different opening and wire diameter than that called for in the screen scale, provided the resultant opening is the same as the nominal opening within a small range of variation. This will make possible the use of sieve cloth now on the market of such variety that nearly all the sieves of the standard screen scale can be constructed in accordance with the specifications without the immediate necessity for weaving special cloth. Later when sieves can be constructed more nearly in accordance with the specifications, the present tolerances will be reduced, and further restrictions will undoubtedly have to be imposed; particularly in regard to the sieving values of the finer sieves, the uniformity of which is especially difficult to control. In this connection, the present standard No. 200 cement sieve, which fortunately appears in the new series without alteration of either opening or wire diameter has such a limitation upon its sieving value. This restriction has been imposed after a very careful study, the results of which will stand in good stead in the later standardization of the new sieves.

Paragraph 7. The Bureau of Standards hereby announces that it will test sieves of this series to determine whether they conform to specifications given below. This test will consist of the examination of the openings of both the warp and shoot of the cloth to ascertain whether they come within the tolerance allowed; also measurements

Table of fundamental data relating to sieves of the standard screen scale

SIEVE NUMBER	SIEVE OPENING	SIEVE OPENING	WIRE DIAMETER	WIRE DIAMETER	TOLERANCE IN AVERAGE OPENING	TOLERANCE IN WIRE DIAMETER	TOLERANCE IN MAXIMUM OPENING	MESH PER CENTIMETER	MESH PER INCH
	mm.	*inches*	*mm.*	*inches*	*per cent*	*per cent*	*per cent*		
2½	8.00	0.315	1.85	0.073	1	5	10	1 0	2.6
3	6.72	0.265	1.65	0.065	1	5	10	1.2	3.0
3½	5.66	0.223	1.45	0.057	1	5	10	1.4	3.6
4	4.76	0.187	1.27	0.050	1	5	10	1.7	4.2
5	4.00	0.157	1.12	0.044	1	5	10	2.0	5.0
6	3.36	0.132	1.02	0.040	1	5	10	2.3	5.8
7	2.83	0.111	0.92	0.036	1	5	10	2.7	6.8
8	2.38	0.094	0.84	0.033	2	5	10	3.0	7.9
10	2.00	0.079	0.76	0.030	2	5	10	3.5	9.2
12	1.68	0.066	0.69	0.027	2	5	10	4.0	10.8
14	1.41	0.0557	0.61	0.024	2	5	10	5.0	12.5
16	1.19	0.0468	0.54	0.021	2	5	10	6.0	14.7
18	1.00	0.0394	0.48	0.0187	2	5	10	7.0	17.2
20	0.84	0.0331	0.42	0.0165	3	5	25	8.0	20.2
25	0.71	0.0278	0.37	0.0146	3	5	25	9.0	23.6
30	0.59	0.0234	0.33	0.0129	3	5	25	11.0	27.5
35	0.50	0.0197	0.29	0.0113	3	5	25	13.0	32.3
40	0.42	0.0166	0.25	0.0098	3	5	25	15.0	37.9
45	0.35	0.0139	0.22	0.0085	3	5	25	18.0	44.7
50	0.30	0.0117	0.188	0.0074	4	10	40	20.0	52.4
60	0.25	0.0098	0.162	0.0064	4	10	40	24.0	61.7
70	0.21	0.0083	0.140	0.0055	4	10	40	29.0	72.5
80	0.177	0.0070	0.119	0.0047	4	10	40	34.0	85.5
100	0.149	0.0059	0.102	0.0040	4	10	40	40.0	101.0
120	0.125	0.0049	0.086	0.0034	4	10	40	47.0	120.0
140	0.105	0.0041	0.074	0.0029	5	15	60	56.0	143.0
170	0.088	0.0035	0.063	0.0025	5	15	60	66.0	167.0
200	0.074	0.0029	0.053	0.0021	5	15	60	79.0	200.0
230	0.062	0.0025	0.046	0.0018	5	15	60	93.0	233.0
270	0.053	0.0021	0.041	0.0016	5	15	60	106.0	270.0
325	0.044	0.0017	0.036	0.0014	5	15	60	125.0	323.0

Note: In order to utilize cloth now on the market, it will be permissible, until notice is given to the contrary, to use wire whose diameter is within a tolerance of 10 per cent for the first three groups and 20 per cent for the last two groups.

of the diameter of wires in each direction to determine the average diameter, and a measurement of any large openings to ascertain whether they exceed the limits of these specifications; also an examination of the sieve to discover any imperfections of the sieve which may seriously affect the sieving value. Sieves which pass the specifications will be stamped with the seal of the Bureau of Standards and will be given an identification number, and a certificate will be furnished for each sieve that passes the requirements.

Paragraph 8. For sieves which fail to meet the specifications, reports will be rendered showing wherein the sieve was not up to the standard.

Paragraph 9. A nominal fee will be charged by the Bureau of Standards for the test and certification of sieves submitted for this purpose.

Paragraph 10. In the table attached hereto are given in the first column the arbitrary designation numbers of the sieves, as explained in Paragraph 4. It may be noted that the series contains 31 sieves which may be conveniently divided into five groups, the first containing 7 sieves, and the other four containing 6 sieves each. The designation of the first three sieves is necessarily irregular, but the others of the first group number consecutively up to and including No. 7. In the second group, beginning with No. 8, the designation numbers are the successive even numbers; in the third group, beginning with No. 20, the designation numbers are the successive multiples of five; in the fourth group, beginning with No. 50, the designation numbers are multiples of ten, as are also those in the fifth group, except the last sieve in the series. These relations will assist the user of the sieves to readily memorize all the designation numbers, and by memorizing the openings of the first four sieves in the series all the others can be reproduced by successive division of those numbers by multiples of 2. It will be observed, also that all the imposed tolerances hold without change for any given group. In columns 2 and 3 are given the width of the sieve openings, and in columns 4 and 5 the wire diameters, in millimeters and inches respectively. Columns 6, 7, and 8 give the tolerances that will be allowed in the width of average opening, in wire diameter, and in the width of maximum opening respectively. These tolerances will be subject to change later as may seem desirable or necessary from experience with the new sieves. It may be remarked, however, that the tolerances in openings have been made as small as wire cloth

now on the market will permit. The tolerance in maximum opening is believed to be ample to meet the accidental variations in weaving cloth, and is designed to eliminate cloth of non-uniform quality. As promptly as the availability of the new sieves will permit, fundamental standards will be established and maintained at the Bureau of Standards as reference sieves. These are especially necessary in respect to the finer sieves, of which the "sieving value" cannot be controlled with sufficient accuracy by the prescribed tolerances. These fundamental standards will make possible the preparation of standard fineness samples of graded material, which will be placed at the disposal of owners and users of sieves for the purpose of checking up their own sieves against fundamental standards. In columns 9 and 10 are given the number of meshes of the various sieves per centimeter and per inch respectively. It may again be emphasized, however, that reference to the number of meshes per unit length serves no useful purpose, and should be discontinued unless the size of the opening is also stated.

Paragraph 11. As stated in an earlier paragraph, the screen scale is essentially metric, and sieves will be certified in the metric dimensions. This is merely a matter of convenience and is not in any sense an attempt to introduce the metric system where the English system might be preferred by some. Rarely would a case be found, however, in which the transition from English to metric units would be more convenient than in the adoption of this standard screen scale. Thus, users of sieves will appreciate that for most purposes a very complete mechanical analysis of a graded material could be obtained by the use of every other sieve in the series, and that if the results of a mechanical analysis were plotted by any one of the usual methods, the same curve would result whether the odd sieves or the even sieves were used. Fortunately for those who prefer not to depart from the English system, it happens that the opening of the No. 3 sieve is almost exactly (well within the tolerance specified) one-fourth inch, similarly the opening of the No. 6 sieve is one-eighth inch, the opening of the No. 12 sieve is one-sixteenth, and so on. Thus, one may use the new screen scale, and readily correlate it with all that he has been familiar with in the use of the old sieves. To those who prefer to work in the metric units the basic 1 mm. sieve, or No. 18, would naturally be included in their selection of sieves from the scale, and this would involve every alternate, or every fourth sieve above and below the basic sieve, but

would not include those sieves of which the openings are very nearly even fractions of an inch. For many purposes either of these series of alternate sieves would serve equally well, but in many cases there would be a decided advantage in employing those sieves of which the openings involve even fractions or multiples of the millimeter. Whatever the selection made, however, and for whatever purpose, the advantage of the fixed ratio in the successive sieve openings is well established, and there is every reason to believe that the sieves are sufficient in number and sufficiently close together to meet every testing requirement.

Paragraph 12. Experience has demonstrated the advantage of having standard testing sieves so designed and constructed that they meet the following requirements:

(a) They should be of sufficient depth to minimize the loss of material during test.

(b) The total height of sieve and pan should be such as to allow the operator to hold the combination firmly in one hand without undue fatigue during test.

(c) The sieve and pan should be preferably of copper or brass and seamless, and sufficiently strong and rigid to stand ordinary laboratory treatment.

(d) All crevices in sieve, pans, and covers where material might lodge should be smoothly soldered.

(e) All sieves, pans and covers furnished by different manufacturers should be interchangeable, and therefore preferably of the same pattern.

(f) Standard testing sieves should be preferably 20 cm. in diameter, this being the inside dimension of top of sieve, and the outside dimension of bottom of sieve.

(g) Covers, sieves and nesting pans should fit loosely, and not tightly, and should have rims of sufficient depth to prevent accidental loss of material during test.

On the basis of these requirements, a specification for sieve frames, covers, pans, and nesting pans, will eventually be included as a part of the general specifications for sieves, which follow. At present this matter is receiving consideration and will be submitted for approval in the near future.

SPECIFICATIONS FOR SIEVES OF THE STANDARD SCREEN SCALE

Paragraph 1. Wire cloth for standard sieves shall be woven (not twilled, except that the cloth of No. 230 (0.062 mm.), No. 270 (0.053 mm.), and the No. 325 (0.044 mm.) sieve, may be twilled until further notice), from brass, bronze, or other suitable wire and mounted on the frames without distortion. To prevent the material being sieved from catching in the joint between the cloth and the frame, the joint shall be smoothly filled with solder, or so made that the material will not catch.

Paragraph 2. The opening of any given sieve should be that given in Column 2 of the attached table, and shall not differ from this amount by more than the "Tolerance in average opening" given in Column 6.

The diameter of the wires of the cloth of any given sieve should be that given in Column 4 of the attached table, and the average diameter of the wires shall not differ from this amount by more than "Tolerance in wire diameter" given in Column 7.

No opening between adjacent parallel wires shall be greater than the nominal width of opening for that sieve by more than the "Tolerance in maximum opening" given in Column 8 of the attached table.

Paragraph 3. The Bureau of Standards also reserves the right to reject sieves for obvious imperfections in the sieve cloth or its mounting, as for example, punctured, loose, or wavy cloth, imperfections in soldering, etc.

THE ASSOCIATION'S POLICIES[1]

The honor of serving as President of the American Water Works Association carries with it commensurate responsibilities. While I deeply appreciate the confidence expressed in being called to serve in that capacity, I am fully aware of the difficulties lying ahead.

We cannot return unchanged to pre-war conditions, and we have laid upon us now during the period of transition the duty of determining what out own future will be. During the war we had the consolation and the excuse that every move was made under an emergency whereas now each step taken is a tie into a definite future. This is a situation that prevails in our Association as well as in our individual enterprises.

The finances of the Association must be adjusted to the new standards now prevailing. Ways and means must be devised to secure an income more equitably adjusted to our necessary expenditures, which doubtless can be most readily obtained by an increasing membership.

The most effective appeal to prospective new members lies in service rendered or to be rendered by the Association to the water works fraternity. The proposal to increase the number of issues of the JOURNAL from four to six per year, and to change its essential character from a recorder of past events to a messenger of current news will place an asset in the hands of the Membership Committee that can be used with the individual operator and the municipal or private corporations which he represents. Membership in a body of two thousand is worth more than membership in a body of twelve hundred, and the more we grow the greater will be our rate of increase.

We claim to be, and are, a national organization of water works men. To continue effectively as such the broad view and not the local must prevail in our councils. The need of concerted action with power and weight of numbers and influence behind it was emphasized during the war when the lack of a strong representative

[1] Address by Carleton E. Davis, President-elect, at the annual convention at Buffalo, June 10, 1919.

body placed the water works of the country at a disadvantage in appearing at Washington before the Priorities and similar controlling commissions.

In a timid way we have coöperated in the past with the American Committee on Electrolysis. It is a sign of growth that we have now decided to continue action on that Committee in a vigorous and thoroughly safe manner.

Another sign of expansion in a national field is the suggestion to use our influence to secure a collection and tabulation of water works statistics by the United States Census, in a manner similar to that now done in the field of other public utilities.

Such activities have doubtless influenced the suggestions made that serious thought must be given the relations of the various sections to the central body and particularly as their mutual interest may affect the annual conventions and the nature of the program to be followed on such occasions. There appears to be well-nigh unanimous concurrence in the belief that we are on the eve of important events and possible changes, but we all approach the solution of any difficulties with a feeling of confidence that the future holds more than the past.

REPORTS OF COMMITTEES

REPORT OF COMMITTEE ON STANDARD FORM OF CONTRACT

Betterments to contracts and specifications have always been and probably will continue to be a fruitful topic of discussion among those actively dealing with the subject.

Recently the question has received more than usual attention. In part this is due to the practices established by the Federal Government as emergency measures incident to the war. But more particularly at the present time, with the abnormal market as to labor and materials are contractors, supply men, bonding companies and financial institutions scrutinizing more critically than before the widely varying types of contracts and specifications coming to their attention.

This broad subject is under active discussion by contractors' organizations and some engineering societies, as has been true for some in the past, At the annual meeting of this association in St. Louis in 1918 the topic was broached with the view to promoting standardization in so far as such a step was practicable. This Committee was appointed to review the subject on evidence now available.

Standardization in the sense of unifying scope and arrangement of form of contract and specifications, eliminating repetitions and redundances, stating concisely what is wanted as contrasted with the use of many words having but little or no meaning for the specific accomplishment to be attained, is well worth while. In particular should measurement and payment clauses be freed from uncertainties which sometimes prove so bothersome to contractors, bonding companies and others.

It should not be forgotten that materials are now better specified than formerly as a result, among other agencies, of the commendable work of the American Society for Testing Materials and of our Association as regards water pipe.

The American Institute of Architects has done good work in stabilizing specifications for the types of work with which they most frequently come in contact. The United States Bureau of Public Roads has recently raised the standard of specifications for road work in many states where previously insufficient attention had

been given to omission of needed clauses and correction of indefiteness of clauses as to methods, materials, measurement and payment.

But when it comes to an actual program of literal standardization there are serious obstacles of which some may be mentioned as follows:

1. Municipal codes and varying city charter requirements demand coördination of contracts with local laws.

2. Law officers of many cities are exceedingly loth to have superseded such sections of contracts as have been passed on favorably to the interests of the city by courts having jurisdiction in the matter of contracts. The same is true of paragraphs to which have been added clauses or sentences covering omissions or weaknesses of earlier phraseology on which the courts have rendered opinions unfavorable to the interest of the municipality.

3. Engineers and superintendents of construction are loth to make a change in contracts and specifications with which contractors bidding on the work are accustomed. This seems to be true even where there is a pronounced discrepancy between work as specified and work performed, indicating that contractors sometimes pay little attention to the contract.

In other words many believe that a state of change is a state of danger, notwithstanding that work better performed would be worth more to the owner than the resulting increased cost.

Between these two conflicting views are those of men who believe that all connected with construction work should employ their influence fully to better the form of contract and specification wherever opportunity presents; that general interest should be stimulated in the subject, both as regards those who in the past have been satisfied with whatever the precedent of their office affords and also with the view of educating public opinion among men in this field to the end that various organizations will get together and advance coöperatively this general question.

It is suggested that the Association arrange, and publish due notice in the JOURNAL, for the purchase, by the members of the Association at nominal price, of typical contracts and specifications aimed toward betterment as viewed by those who have given the subject most study, for example the specifications of the American Institute of Architects, the outline guide of the Bureau of Public Roads and the specifications of cities such as St. Louis which have

recently rewritten and condensed their standard form of contract and specification.

It is further suggested that at the next convention arrangements be made for papers on this subject by representatives of some contractors' organization and of a bonding company experienced in the contract field.

Feeling that this subject is one on which a systematic campaign of education might well be adopted and that there is very little work to be done until the above suggestions and similar steps have been carried out this committee requests its discharge.

GEORGE W. FULLER,
LEONARD METCALF,
EDWARD E. WALL.

REPORT OF ASSOCIATION'S REPRESENTATIVES ON AMERICAN COMMITTEE ON ELECTROLYSIS

During the war, the American Committee on Electrolysis was not active because its members were too busy with other duties. After printing "A Preliminary Report Prepared for Submission to its Principals by The American Committee on Electrolysis" in 1916, the Committee appointed a Technical Sub-committee to plan a further report on the prevention or mitigation of electrolysis. This sub-committee, having one representative from each organization in the main committee, submitted on February 23, 1917, a carefully prepared outline as follows:

INTRODUCTION.
- A. PRINCIPLES, DEFINITIONS AND THEORY.
- B. TECHNICAL FEATURES OF CONSTRUCTION AND OPERATION.
  - I. Features of primary construction which tend to reduce trouble from electrolysis.
    - 1. Railways.
      - a. Bonding and cross-bonding.
      - b. Improvement of track insulation.
      - c. Reinforcement of rail conductivity.
      - d. Interconnection of tracks.
      - e. Use of additional power supply stations.
    - 2. Affected structures.
      - a. Favorable location with respect to tracks.
      - b. Pipes laid with insulating joints.
      - c. Avoidance of contacts between cables.
      - d. Insulation of cable sheaths from earth.
      - e. Insulation of pipes from earth.

II. Remedial Measures.
1. Measures Applicable to Railways.
a. Insulated track feeder system.
b. Three-wire system.
c. Reversed polarity of trolley systems
d. Double trolley systems.
e. A. C. systems.
f. Summary.
2. Measures Applicable to Affected Structures.
a. Surface insulation.
b. Insulating joints.
c. Drainage systems for cable and pipe.
d. Shielding, or the use of an auxiliary anode.
e. Summary.
III. Joint Responsibility of Interests and Necessity for Coöperation.
IV. Conclusions and Recommendations.
1. Primary construction and location.
2. Power supply and distribution.
3. Use and limitation of track feeder system.
4. Use and limitation of drainage system.
5. Other measures.

C. Standard Methods of Making Electrolysis Surveys.
I. Potential Surveys.
1. Overall potential measurements on tracks.
2. Potential gradient measurements in tracks.
3. Potential differences between affected structures, rails, other conductors and earth.
4. Equipment for potential measurements.
II Current Measurements.
1. Current in feeders and rails.
2. Current in pipes, cable sheaths and other affected structures.
3. Measurement methods and equipment needed for *1* and *2*.
4. Leakage current from affected structures, methods and equipment.
III. Other Measurements.
1. Bond testing.
2. Resistance between tracks and earth.
3. Earth resistance.
4. Resistance of pipe joints.
5. Determination of source or sources of stray current.
6. Location of concealed connections.
IV. Interpretation of Results of Survey.

D. European Practice.

E. Appendices and Data.

On February 17, 1919, the Technical Sub-committee met again to revise the work interrupted by the war. On March 31 the main committee met to consider the recommendation of the Technical Sub-committee. Fifteen members were present, each of the eight organizations constituting the main committee being represented. Your two representatives were among them. At this meeting the outline for the second report given above was unanimously adopted.

During the period of enforced inactivity on the part of the Committee, the Bureau of Standards had continued its routine observations and had planned more extensive investigations of electrolysis. To give each organization in the Committee opportunity to share in the direction of these investigations, to get full benefit from them and to contribute services which would make them more complete and authoritative, the Bureau proposed the appointment of a committee of experts to work with its staff. These experts were to be selected and paid by the organizations, each organization having its own, unless it should be found practicable and satisfactory for two or more kindred organizations to unite for the sake of economy. To do the work expected, each expert would necessarily devote much of his time to it. It was roughly estimated that at a fair rate of compensation, with reimbursement for traveling expenses, the cost for each expert would approximate $3000 for the year.

Records of important actions at the meeting of March 31 are quoted from the official minutes as follows:

> As the Technical Subcommittee had recommended that the plan of cooperative work with the Bureau of Standards be adopted, this matter received extended discussion. This brought out the general trend of opinion that such coöperation was very desirable and should be carried out through a small working subcommittee of experts who could devote sufficient time to this subject to advise with the Bureau of Standards on new work to be undertaken, to keep in close touch with the progress of such work, and to participate in drawing conclusions from the results of the work.
>
> Dr. Rosa, speaking for the Bureau of Standards, stated that if competent engineers representing the committee should be appointed, the Bureau would submit to these experts all of its information and data, would discuss with them the conclusions drawn from such data and would submit to the committee in advance of publication, for discussion and criticism, all its reports and technical papers. This plan would enable the Bureau to profit by such expert advice and criticism and would enable the American Committee on Electrolysis to know more of the work of the Bureau as it progressed and to have a part in the planning and execution of such work.

Resolved, that the report of the Technical Subcommittee, of February 23, 1917, be approved and four committees, A, B, C, and D, be appointed to carry out the program of work contained in that report.

These subcommittees are as follows:

A. Principles, definitions and theories.
B. Technical features of construction and operation.
C. Methods of making electrolysis surveys.
D. European practice.

The following motion was offered by Mr. Flinn and unanimously carried, the motion being intended to provide for the fullest coöperation of the committee with the Bureau and of the Bureau with the committee.

Resolved that the American Committee on Electrolysis appoint a subcommittee of four members with which the Bureau of Standards is requested to collaborate in conducting investigations of electrolysis for the purpose of carrying out the program proposed by the Technical Subcommittee in its report of February 23, 1917, the new subcommittee to be composed of one representative each of the water, gas, lead cable and railway interests, and to coöperate with the Technical Subcommittee, and

Resolved that this new subcommittee may be represented in its work by experts engaged severally by the interests named, subject to the approval of the Chairman of the American Committee on Electrolysis, and

Resolved that this subcommittee report monthly its activities and conclusions, sending copies of such reports simultaneously to the Chairman of the American Committee on Electrolysis and each member thereof, and

Resolved that this subcommittee be authorized to coöperate with the Bureau of Standards in all of its work which can contribute to the attainment of the objects of the American Committee on Electrolysis.

On motion of Mr. Katté it was

Resolved that this subcommittee of four to coöperate with the Bureau of Standards be increased to six in order to include the Electric Light and Power companies and the Steam Railroads separately.

This would provide for two representatives of the pipe interests, two of the lead cable interests and two to represent the railway interests. This resolution was adopted with only one negative vote."

It was agreed that the Committee on Coöperation with the Bureau of Standards consisting of six members would be appointed when nominations are made by the different interests and that any technical experts employed are to serve on this committee of coöperation.

Subsequently, it was agreed that the coöperative committee should have seven members, one each of the members of the main committee from the seven organizations other than the Bureau of Standards. It was also understood that each member of this cooperative committee, unless himself to serve as an expert, should be responsible for the direction of the expert engaged by his organization to work with the Bureau. Mr. Flinn nominates Mr. Edward E.

Minor as the member from the American Water Works Association on this coöperative committee. Prof. Louis A. Hazeltine, professor of Electrical Engineering at Stevens Institute of Technology, Hoboken, New Jersey, is suggested as a suitable expert. He was closely associated with Professor Ganz until the latter's death, and is now consulting engineer to Albert F. Ganz, Inc. He is independent of commercial interests concerned in electrolysis, and competent.

The officers of the American Committee on Electrolysis are: Chairman Bion J. Arnold, consulting engineer, Chicago; Secretary Dr. E. B. Rosa, Chief Physicist, Bureau of Standards, Washington; Treasurer D. W. Roper, Superintendent of Street Department, Commonwealth Edison Co., Chicago, Ill. The Treasurer's financial statement, as of March 1, 1919, showed total receipts amounting to $2003, total expenditures $851 and balance $1152, with which to meet miscellaneous expenses.

At present there is a vacancy in the representation of the American Water Works Association on the American Committee on Electrolysis. It is urged that an appointment be made without further delay, so that the work of the Committee may proceed actively.

Your representatives are impressed with the significance of the existence of the American Committee on Electrolysis, combining all interests, the ability of the men on this Committee, their earnestness, the spirit of fairness and frankness which animates the Committee, and the importance of the work in hand. The American Water Works Association cannot afford to take other than an active part consistent with the magnitude of the interest for which it stands. It is believed that the funds needed to employ an expert to work with the Bureau of Standards can be raised by subscription on suitable appeal.

The undersigned recommend, therefore, authority be granted for the employment of such an expert and that a special committee be appointed to collect the necessary funds. These funds should be paid to the Treasurer and disbursed by him on proper vouchers.

EDWARD E. MINOR.
ALFRED D. FLINN.

REPORT OF THE FINANCE COMMITTEE FOR THE FISCAL YEAR ENDING MARCH 31, 1919

The Finance Committee present the following report on the financial operations of the Association for the fiscal year ending March 31, 1919.

We have audited the books of the Secretary and Treasurer and have found them correct. We have examined and verified all vouchers. Details of the financial operations of the Association are set forth in the respective reports of the Secretary and Treasurer and are in accordance with their books. Following is summarized statement of the past year's accounts:

Summarized statement of accounts for the fiscal year ending March 31, 1919

Balance on hand in Bank April 1, 1919	$1,487.70	
Received from the Secretary	10,555.56	
Interest on Investments and Deposits	592.46	
Total		$12,635.72
There was disbursed and paid by the Treasurer on vouchers duly authorized and audited by the Finance Committee for the general operations of the Association	$9,096.36	
There was added to the permanent investment fund	1,936.33	
Total		$11,032.69
Leaving on April 1, 1919, a balance in bank to the credit of the Association of		1,603.03

PERMANENT INVESTMENT FUND

There are now in the hands of the Treasurer, by authority granted the Finance Committee by the Executive Committee, certificates constituting the Permanent Investment Fund of the Association as follows:

Four $1000 Dominion of Canada 5% Bonds, due April 1, 1931	$ 4,000.00
Two $1000 American Foreign Security Company 5% Notes, due August 1, 1919	2,000.00
Four $500 United States First Liberty Loan Bonds, 3½%	2,000.00
One $1000 United States Second Liberty Loan Bond, 4%	1,000.00
Two $1000 United States Third Liberty Loan Bonds, 4½%	2,000.00
Two $1000 United States Fourth Liberty Loan Bonds, 4½%	2,000.00
Par Value of Permanent Investment Fund	$13,000.00

An obligation of $1000, on the balance on hand in bank April 1, 1919, was made by the Treasurer in the form of a subscription for one United States Victory Loan Bond for that amount.

It is gratifying to note that on April 1, 1917, the par value of the Permanent Investment Fund was $6000, and that in the last two years this figure has been more than doubled. It is desirable to build up a sizable investment fund, but it is equally desirable, where the best interests of the Association dictate such action, that the surplus receipts of the Association be expended so that a healthy and progressive condition will result. Definite recommendations will be made in this line further on in this report.

BUDGET ALLOWANCES AND DISBURSEMENTS, 1918–1919

Following is a staement of the budget allowances for the past fiscal year and of the disbursements against each item:

Item	*Budget Allowances*	*Disbursements*
Convention Expenses	$700.00	$681.77
Office Expenses	700.00	569.37
Election Expenses	200.00	179.54
Committee Expenses	1,000.00	951.25
Section Expenses	600.00	275.76
Insurance	75 00	65.82
Salary of Secretary	1,500.00	1,500.00
Salary of Editor	800.00	800.00
Printing JOURNAL	5,500.00	3,421.88
Contingencies	425.00	160.48
Totals	$11,500.00	$8,605.87

There was also disbursed for the benefit of members the sum of $491.02 for authors' reprints, pipe specifications, etc., thus making the total disbursements for the year $9,096.36.

From the above it will be noted that in no instance did the expenditure under any item in the budget exceed the allowance. The printing of the JOURNAL cost $3421.88, or $2078.12 less than the allowance. The report of the Publication Committee contains certain pertinent suggestions on this subject, all of which are heartily concurred in by your Finance Committee. It is proposed to print the JOURNAL in six numbers each year instead of in four, in an endeavor to make the Association publication a wholly worthy pro-

duction. The suggestion is timely and wise, in the opinion of your Committee.

The receipts of the Association for the last year exceeded the disbursements for expenses by approximately $2052. This may be considered a fair criterion on which to figure. There appears to be no real necessity of adding further to the permanent investment fund, for the present at least. On August 1, 1919, the two $1000 American Foreign Security Company notes fall due. This added to the probable surplus for the current year will provide a fund amounting to about $4000, which, in the opinion of your Committee, cannot be more wisely applied than in producing a better JOURNAL.

This radical departure from past practice appears to be justified. The Association can never hope to become bigger and better without improving its JOURNAL. It is the only direct return the majority of the members receive for their annual dues. The proposed program can be tried out this year, and whether or not it will be advantageous to continue it next year the results of the current fiscal year will show.

RECOMMENDED BUDGET FOR THE YEAR 1919–1920

For the fiscal year 1919–1920 the following budget allowances are recommended:

Item	*Expended 1918–1919*	*Recommended 1919–1920*
Convention Expenses	$681.77	$700.00
Office Expenses	569.37	700.00
Election Expenses	179.54	200.00
Committee Expenses	951.25	1,000.00
Section Expenses	275.76	400.00
Insurance	65.82	75.00
Salary of Secretary	300.00	500.00
Salary of Assistant to Secretary	1,200.00	1,200.00
Salary of Editor	800.00	1,000.00
Printing JOURNAL	3,421.88	7,500.00
Contingencies	160.48	225.00
	$8,605.87	
Author's copies, etc	491.02	
Totals	$9,096.89	$13,500.00

In addition to the larger budget allowance for the JOURNAL, increases will also be noted in the salaries of the Secretary and Editor. The honorariums they now receive are all too small, and the slight increase herein recommended is more of an expression of confidence and appreciation of their efforts than a direct attempt to pay them for the work they do.

This year the question has arisen as to whether the Association, in addition to paying the expenses of the Secretary, Treasurer and Editor when attending the annual convention, should also pay the similar expense of the Assistant to the Secretary. The Finance Committee took the position that such expenses should be paid by the Association on the basis of four cents per mile of travel, as provided for under Article 8, Section 5, of the revised constitution. The Assistant to the Secretary performs highly important duties of an executive character at these conventions which can ill be dispensed with, and to engage outside assistance to do this work would entail at least an equal expense with a concurrent sacrifice of efficiency. We trust that the Association will approve our action and direct the continuation of the practice of paying the convention expenses of the Assistant to the Secretary, on the basis of four cents per mile of travel, to and from the place of meeting. Suitable provision for this item has been made in the recommended budget for the current year.

In concluding this report we feel impelled again to call attention to the necessity for increased activities on the part of all members in the line of securing new members, and also in the production of a high grade JOURNAL. The official publication of an Association reflects the value of the organization to the public at large and to the Association in particular. We feel that one of the special efforts of this convention should be directed to the formation of a definite program whereby the JOURNAL may be made distinctly better through the acquisition of high class papers dealing with a wide variety of subjects.

Our net loss in membership was only thirty-nine last year, and while an actual increase would have been desirable, yet under the war conditions the loss was not as great as was anticipated. Particular effort needs be made to obtain new members, and in our opinion a special committee on membership should be appointed, and that likewise on this committee every Section of the Association should be represented.

The Treasurer is under bond for $10,000 as per order of the Executive Committee. The bond is in the custody of the Chairman of the Finance Committee.

This committee desire to express their appreciation of the co-operation they have received from the Secretary, the Assistant to the Secretary, the Treasurer and Editor, and other officials of the Association. Harmony has reigned in all of our activities.

GEORGE A. JOHNSON,
Chairman.
J. WALDO SMITH,
FRANK A. BARBOUR,
Finance Committee.

REPORT OF THE PUBLICATION COMMITTEE

It is customary for the Publication Committee to make a report or verbal statement annually to the Association. Your Committee is accordingly submitting its views on its work during the current year and its opinions regarding further work of this character.

Owing to war time conditions, little was done during the last year in developing the activities of Sections. At the St. Louis convention a large part of the papers presented there were turned over to the special committee appointed to consider the cold weather problems of the water departments. These two facts left your Committee with less than half the number of papers usually available for publication in the JOURNAL. Some of the most interesting papers were withdrawn by the authors for one reason or another. It became necessary, therefore, to secure material from other than the usual sources, or to give up the publication of one or more numbers of the JOURNAL.

Rather than abandon the program of publication an attempt was made to secure contributions from the members of the Association. For several months the response to your Committee's efforts was practically nil, but since the beginning of the current year there has been a slowly increasing interest in the work of the Committee, and it is now our belief that the members will eventually become helpful coöperators with the Committtee if the Association decides to continue the recent policy of attempting to publish a JOURNAL containing original papers as well as those presented before the annual convention and at Section meetings.

The question to be settled by a man asked to join the Association is this: Is it worth $5 a year to receive the JOURNAL, to have the privilege of attending the annual convention and in some cases the meetings of the Sections, and to contribute toward the expenses of committees investigating problems which may or may not be of interest to him? To the average water works man the JOURNAL is the only substantial return and it is not now worth $5 a year to him.

The main reason why the JOURNAL is not worth $5 is that the cream of the information published in it is published in trade papers before the Association prints it. The trade papers condense the papers presented to the Association so that their elaboration is avoided and the needs of the average readers are met to a considerable extent. When these papers by our members are printed by the Association they have been robbed of their novelty. It has been repeatedly suggested that the papers should be withheld from publication until they have been printed by the Association. This is an undesirable policy, for a purpose of the Association is to disseminate information of value to those engaged in water supply and the trade press is a most valuable means to this end. The logical deduction from the facts is that the Association should either publish only the papers presented before the annual convention and the Sections in a single annual volume, or it should publish the JOURNAL more often and make it a magazine of first-hand information as well as the place of final publication for the convention and Section papers.

In considering the comparative advantages of these two courses, most weight should be given to the relative importance of three things the Association has to offer a man asked to join its ranks. The increase in membership due to the opportunities for social intercourse has been urged for a good many years without any material increase in our roll call. Although this is an advantage appreciated by many of the present members, it is apparently unattractive to persons not already members. The usefulness of joining the Association in order to assist to the extent of $5 annually in committee work of an indefinite nature is difficult to make apparent. The last Publication Committee called attention to certain useful extensions of committee work, but war conditions made it inadvisable to attempt them heretofore. It is believed that the new officers of the Association should give attention to the recommendations in that report, for the development of closer relations between the members, which was their object, is absolutely essential to arouse the Association from its lethargic condition.

The most attractive advantage of membership which the Association can offer is a JOURNAL which contains a considerable amount of original information, appears more often than the present JOURNAL and is not sold to anybody at less than the annual dues of a member, except to newsdealers and booksellers who will charge their customers full price. This JOURNAL would not be an engineering magazine, of which there are now enough in existence, but a water-works magazine covering all branches of water works affairs. The lack of interest of some of the members in the JOURNAL six months ago made this seem an impossible project at that time, but interest has developed and the plan seems worth trying for one year, provided the members will agree to two essentials: first, to provide adequate funds, at least $7500 for a magazine appearing every second month, and, second, to agree to support the Publication Committee in its policy of editing the papers.

The handling of some of the papers presented at Section meetings and the annual conventions is a problem of many difficulties. The trade papers condense the best of these papers and print them practically as soon as read. Probably three-fourths of the members are satisfied with the amount of information presented in these abstracts. The information left out in preparing the abstracts may be anywhere from one-fourth to three-fourths of the entire papers and usually consists of tables and illustrations expensive to print. Sometimes the author repeats the same information in text, tables and illustrations, something never permitted in a well-edited magazine. Occasionally the author even insists upon rearranging large masses of tabulated figures several times, so as to show different relations between them, apparently unconscious of the fact that when they have been given once to show certain relations every intelligent reader is willing to admit that the author is competent to rearrange them in a different way without error and to accept his word that when so arranged the sums of the various columns are the quantities he states.

The cost of publishing the JOURNAL has increased one-third during the past fiscal year. The opportunities to reduce the unit costs of publishing during the next twelve months are slim, but none which present themselves will be passed without careful investigation. To print six numbers instead of four in a year and to print a considerable amount of original matter as well as the convention and Section papers, the Publication Committee must have the same

control editorially over the papers that is exercised by the editor of a trade journal. This control is granted by the Association's Constitution, but a few members question it and there should be no uncertainty on this point. It is necessary in order to handle the financial problems of publication adequately. There should be no increased charges for advertising in six numbers annually over that for advertising in four numbers, until the Association and the JOURNAL show greater influence. There is no better advertising medium for pipe, pumps, pumping station equipment, water purification equipment and a great variety of supplies, but this fact will become more apparent when the Association and its JOURNAL show more clearly by continuous effort that they are distinctly useful. Until that demonstration is made there are no grounds for expecting the advertising revenue which the JOURNAL will have when it has been thoroughly established.

CARLETON E. DAVIS,
Chairman,
WILLIAM W. BRUSH,
ALLEN W. CUDDEBACK,
GEORGE A. JOHNSON,
JOHN M. GOODELL,
Editor.

REPORT OF THE MEMBERSHIP COMMITTEE

The following number of applications for membership in the American Water Works Association were received and passed by the present Membership Committee during the year ending March 31, 1919: Active, 57; Corporate, 6; Associate, 6; Total, 69.

Fifteen Active members and two Associate members were passed by the preceding committee. The total number of new members elected during the fiscal year was therefore as follows: Active, 72; Corporate, 6; Associate, 8; or a total of 86.

The Membership Committee recognizes the fact that the war has undoubtedly been the cause of many active members resigning from the Association and has also deterred others from joining. It may be of interest to note here the variation in the membership of the Association during the past five years as shown in the published reports of the Secretary. These reports, however, cover the period from September, 1913, to September, 1918, only.

YEAR	ACTIVE	CORPORATE	ASSOCIATE	HONORARY	TOTAL
1914	947	65	117	7	1136
1915	1029	70	123	7	1229
1916	1150	81	123	7	1361
1917	1148	81	123	8	1360
1918	1087	89	125	7	1308

The present Membership Committee feels strongly that the American Water Works Association can and should increase its membership very greatly and thereby extend its field of usefulness. The time seems opportune for the inauguration of such a campaign.

This Committee desires therefore to offer the following recommendations:

First: That an effort be made to establish in every state of the United States in which there are resident twenty or more Active or Corporate members of the American Water Works Association a Local Section of the Association, in accordance with the provisions of Article X, Section 1, of the Constitution. It is not intended that the organization of new sections shall in any wise interfere with Sections already established.

There were on April 1, 1919, as reported by the Secretary, the following Sections of the Association having a membership and covering territory as shown:

		ACTIVE	CORPORATE	ASSOCIATE
Canada—Not officially organized		64	8	1
California		32	5	0
Kentucky, W. Virginia, Ohio, Western Pennsylvania, Indiana, Michigan	Central States	115	15	17
New Jersey south of Trenton, Maryland, Eastern Pennsylvania, Delaware, District of Columbia	4-State	113	9	21
Illinois		92	3	15
Iowa		40	1	1
Minnesota		31	2	1
New York, State of New York and New Jersey south to Trenton		231	16	45

The Canada, California, Illinois, Iowa and Minnesota Sections cover just these territories.

It would be an advantage to the American Water Works Association if the Indiana Sanitary and Water Supply Association and the Southwestern Water Works Association could be induced to become Sections of the American Association.

The Canadian Section should be officially organized, Massachusetts, Connecticut, Missouri, Western Pennsylvania, and Wisconsin already have a sufficient number of members to entitle them to local sections. Two or more neighboring states might unite in forming a joint section, as for example North Dakota and South Dakota, or North Carolina and South Carolina. Maine, Virginia, and Tennessee could no doubt increase their membership by a slight effort so as to entitle them to sections also.

The future growth of the American Water Works Association depends largely on its local sections, as these can best interest the men connected with the smaller water works in their respective localities.

Second: President Henderson has made the following suggestion:

> There should be many more Corporate members. Almost all towns of 5000 and over should hold a Corporate membership so that the constantly changing Superintendents might have the Proceedings and the relief from the necessity of being taken in as new members at every change of administration.

The present Membership Committee desires, therefore, to recommend to the Association that President Henderson's suggestion as presented above be adopted.

Third: It seems desirable that the duties and responsibilities of the Membership Committee be extended and that an appropriation of $300 to $500 per year be granted for the use of the Committee, if such a campaign as outlined above is to be carried out.

Fourth: This Committee would request that the members of the Association be particularly careful when filling out application blanks to give all available information requested concerning the applicant. The Membership Committee can be of little more service than a rubber stamp in judging of the qualifications of an applicant unless the fullest possible information is given.

Respectfully submitted,

LEWIS I. BIRDSALL,
Chairman.
F. C. JORDAN,
W. Z. SMITH.

REPORT OF THE SECRETARY

FOR FISCAL YEAR ENDING MARCH 31, 1919

FINANCIAL STATEMENT

Cash on hand April 1, 1918		$1,487.70
Receipts:		
Initiation fees		$420.00
Annual dues		6,536.00
Advertisements in JOURNAL		2,584.75
Sales of PROCEEDINGS		3.00
Sales of JOURNALS		76.00
Subscriptions to JOURNAL		407.00
Typhoid Toll, sales of reprints		6.80
Authors' copies, profit from		14.56
Interest		581.84
Hydrant and Valve Specifications, sales of		9.25
Jordan Report, sales of		2.25
Depreciation Committee Report, sales of		1.15
Pipe Specifications, sales of		25.91
Uniform Accounts, sales of committee reports		.25
Association badges, sales of		24.00
Total receipts		$12,180.03
Disbursements:		
Office expenses	$ 569.37	
Convention expenses	681.77	
Printing JOURNAL	3,421.88	
Committee expenses	951.25	
Salary of Editor	800.00	
Election expenses	179.54	
Salary of Secretary	1,500.00	
Insurance	65.82	
Section expenses	275.76	
Binding cases	26.13	
Contingencies	160.48	8,632.00
		$3,548.03
Put in Permanent Investment Fund		1,945.00
Balance, cash on hand March 31, 1919		$1,603.03

MEMBERSHIP STATEMENT

Active:			
Last report		1069	
Elected during the year		72	
Paid back dues and restored		12	
		1153	
Losses:			
Resigned	47		
Died	13		
Dropped, "Enemy Alien"	1		
Dropped nonpayment dues	65		
Transferred to corporate	3	129	1024
Corporate:			
Last report		82	
Elected during the year		6	
Paid back dues and restored		2	
Transferred from Active		3	91
Associate:			
Last report		122	
Elected during year		8	
		130	
Losses:			
Resigned	7		
Dropped, nonpayment dues	2	9	121
Honorary:			
Last report		7	
Losses:			
Died		2	5
Total membership April 1, 1919			1241

	Active	*Corporate*	*Associate*	*Honorary*	*Total*
1918	1069	82	122	7	1280
1919	1024	91	121	5	1241
	−45	9	−1	−2	−39

Sixty-seven members took advantage of the "Remission of Dues to Men in the Service" resolution, causing a loss of $335 in dues.

J. M. DIVEN,
Secretary.

ANNUAL REPORT OF THE TREASURER

Permit me to submit my report as Treasurer of the American Water Works Association for the year ending March 31, 1919.

The funds of the Association are on deposit with the Troy Trust Company, Troy, N. Y.

The receipts during the year were as follows:

Balance April 1, 1918	$1,487.70
Received from J. M. Diven, Secretary	10,555.56
Interest on deposits	97.53
Interest on investments	494.93
Total	$12,635.72
Disbursements as per vouchers, cancelled checks and debit slips	11,032.69
Balance, April 1, 1919	$1,603.03

The disbursements include $1,956.33 used for the purchase of U. S. Liberty Bonds for the Permanent Fund.

Attached you will find certificate of the Troy Trust Company showing a deposit of $2,219.33 at the close of business March 31, 1919.

From this balance there should be deducted the following for unreturned checks.

Deposit as per certificate		$2,219.33
Unreturned checks:		
V877—Ck. 1047 Nicholas S. Hill, Jr	$250.00	
881—Ck. 1051 Williams & Wilkins	165.14	
882—Ck. 1052 Edward S. Cole	114.56	
883—Ck. 1053 Henry Stowell & Son	86.60	616.30
Balance, April 1, 1919		$1,603.03

The receipted vouchers, cancelled checks and debit slips with the book of the Treasurer are submitted for audit.

The Permanent Fund now consists of the following:

4—$1,000 Dominion of Canada 15 yr. 5% Bonds.....	$4,000.00
2—$1,000 Am. Foreign Sec. Co. 3 yr. 5% Notes.....	2,000.00
4— $500 U S. Liberty 3½ % Bonds.....	2,000.00
1—$1,000 U. S. Liberty 2nd., 4% Bonds.....	1,000.00
2—$1,000 U. S. Liberty 3rd., 4¼% Bonds.....	2,000.00
2—$1,000 U. S. Liberty 4th., 4¼ Bonds.....	2,000.00
Par value of permanent fund*.....	$13,000.00

* The securities have been examined and checked by J. H. Caldwell, W. P. Mason and J. M. Diven.

The Treasurer receives no salary and is under $10,000 bond as per the order of the Finance Committee.

Respectfully submitted,
JAMES M. CAIRD,
Treasurer.

Troy, N. Y., April 1, 1919.

This is to certify that at the close of business March 31, 1919, there was to the credit of the American Water Works Association a balance of Twenty-two Hundred Nineteen and 33/100 Dollars ($2,219.33) on the books of the Troy Trust Company, of Troy, N. Y.

F. BUNCE,
Treasurer, Troy Trust Co.

SOCIETY AFFAIRS

THIRTY-NINTH ANNUAL CONVENTION

Tuesday morning, June 10, 1919. The convention was called to order at 10.30 a.m. in the convention room of the Hotel Iroquois, Buffalo, N. Y., by the president, Charles R. Henderson. The address of welcome was delivered by Hon. A. W. Kreinheder, commissioner of public works of Buffalo, and differed from most addresses of this sort in that it explained the form of government of the city and particularly the work done by the department of public works. It is printed on page 350. In his reply to this address President Henderson pointed out that the American Water Works Association was organized in the Middle West but came to Buffalo, to the East, for its second convention. This was in 1883. It convened again in Buffalo in 1898, when it had a little more than three hundred members, of whom 61 are still on the rolls. So the thirty-ninth convention is the third to be held in that city.

The committee appointed to canvass the ballots for officers for the next year, James H. Caldwell, William P. Mason and John M. Diven, reported that the following nominees were elected: President, Carleton E. Davis; vice-president, M. L. Worrell; treasurer, James M. Caird; trustees, W. H. Randall and F. C. Jordan. In acknowledging his election, Mr. Davis stated that he was somewhat shocked to learn from the secretary and treasurer that under the terms of the new Constitution prescribing the method of electing officers the election cost the Association over $500, considerably more than $1 per vote cast, the number of ballots received and counted being 382. He did not consider that this was due to Association politics but was merely the result of the methods of conducting the elections which were now obligatory under the Constitution.

The first paper of the convention, on "The Effect of the War Period, 1914–1918, and Public Control upon the Water Works of the United States," was presented by Leonard Metcalf and discussed by Lieut.-Col. Dabney H. Maury, C. W. Wiles,

Walter E. Miller, E. D. McCartney, J. N. Chester, R. B. Howell, F. W. Cappelen, J. W. Ledoux, N. S. Hill, Jr., Henry P. Bohmann, and the author. Upon motion of C. W. Wiles the Association directed the paper to be printed and distributed to the members in advance of its publication in the JOURNAL. (The paper was preprinted in this way in July.)

An informal discussion of damages to fire hydrants by motor vehicles and the remedies for this was opened by W. W. Brush and continued by Carleton E. Davis, C. W. Wiles, F. W. Cappelen, F. T. Kemble, J. N. Chester, Richard Whitney, A. W. Cuddeback, Beekman C. Little, Francis H. Luce, W. S. Cramer, G. E. Shoemaker, Elbert W. Sylvester, William R. Young and E. E. Wall.

Tuesday afternoon, June 10, 1919. After calling the meeting to order President Henderson introduced John Knickerbacker who read a paper on "Investigation of Question of Flanges for Light Cast Iron Pipe," which was discussed by D. W. French, W. H. Randall, and the author. The discussion developed a desire by some of the members of the Association to have the subject considered in connection with investigations of it by other organizations, and the paper was accordingly referred by the President to the Committe on the Revision of Standard Specifications for Cast Iron Pipe and Specials.

The report of the Committee on Private Fire Protection Services was presented by its chairman, Nicholas S. Hill, Jr. The report without the appendices had been preprinted and distributed to all members by direction of the Publication Committee. The report was discussed by J. N. Chester, W. E. Miller, F. W. Cappelen, H. C. Hodgkins, F. E. Beck, Maurice R. Scharff, D. A. Reed, Frank C. Jordan, Patrick Gear, Chester R. McFarland and Mr. Hill. On motion of Mr. Chester the committee was continued with a request to consider its recommendations in the light of the discussion and to bring them before the next convention.

The remainder of the session was devoted to a discussion of a variety of topics introduced informally. Trustee W. S. Cramer presided. A method of stopping leaks in the bottom of reinforced concrete reservoirs was described by D. A. Reed. Troubles with check valves and foot valves were described by D. L. Webster. The practice of electric light companies to ground wires on water pipes was discussed by C. W. Schiedel, Homer C. Crawford, G. T. Maxon, R. B. Howell, and F. T. Kemble. The generation of power

by passing water in a high-service section through a turbine on its way to a low-service section was discussed by W. W. Brush, Alexander Lindsay, A. T. Clark and Chairman Cramer. The removal of iron from water from wells was discussed by F. J. Connor, W. W. Brush and G. C. Habermeyer. The inspection of hydrants during the winter was discussed by David L. Webster, F. J. Connor, Roswell M. Roper and Chairman Cramer.

Tuesday evening, June 10, 1919. President Henderson introduced as the first subject for the session the quality of the local water supply, which was discussed by Henry F. Wagner in a paper entitled "The Buffalo Water Supply, with Special Reference to the Filtration Problem." This was followed by a paper on the "Reduction of Water Consumption by Means of Pitometer Survey and Constant Inspection" by George C. Andrews. A paper on "The Uniflow Pumping Engine" was presented by D. A. Decrow and discussed by J. N. Chester, J. W. Ledoux and the author. A paper on "Air Lift Pumping and Water Purification" by John Oliphant was read in the author's absence by C. G. Cummings.

Wednesday morning, June 11, 1919. The meeting was called to order by President Henderson, who first asked for a discussion of the best methods of cleaning partially clogged service pipes, a subject which was discussed by F. J. Connor and W. E. Miller.

A paper entitled "The Relation of the Chemical Industry of Niagara Falls to Water Works" was read by John A. Kienle and discussed by Lieut.-Col. G. A. Johnson, M. N. Baker, Henry P. Bohmann, H. C. Hodgkins, Maurice R. Scharff and the author.

The trend of prices affecting water works construction and maintenance was discussed by D. F. O'Brien, Charles R. Wood and H. E. Buttenheim.

The report of the Executive Committee was made informally by Carleton E. Davis. The committee recommended changing Section 3, Article X, of the Constitution to read as follows:

> Section 3. Such sections shall consist only of members of this Association in good standing, shall elect their own officers and committees, subject to confirmation of the Secretary of the Association as to their standing in the Association, and may make any rules for their government not inconsistent with the Constitution and By-laws of the Association, but these rules must first be approved by the Executive Committee.

This amendment was adopted.

The committee further recommended that Section 1, Article V, of the Constitution should be amended by adding the following:

Provided that any Active Member in good standing who has paid dues continuously for thirty years shall be exempt from payment of further dues.

Mr. Davis stated that this amendment would apply to 27 members. It was adopted.

Mr. Davis further reported that the Executive Committee had voted to continue the remission of dues of members in active service until they were demobilized, and to remove from the mailing list of the JOURNAL the names of all members of the Association in arrears on July 1 of each year until their dues were paid up.

The report of the Treasurer, James M. Caird, was read; this is printed on page 602.

The report of the Secretary was presented by John M. Diven; it is printed on page 600. He stated that since April 1, the beginning of the Association's year, about seventy applications for membership had been received and about eleven resignations, so that if the report were revised to date it would show that the Association had gained in membership, in spite of war conditions.

The report of the Publication Committee was read by Carleton E. Davis; it is printed on page 594. The report was adopted on motion of Leonard Metcalf.

The report of the Finance Committee was read by Lieut.-Col. George A. Johnson; it is printed on page 590. The report was adopted.

The report of the Membership Committee was read by Lewis I. Birdsall; it is printed on page 597. Mr. Birdsall stated in connection with the report that the committee believed the Association could best help the smaller water works which were unable to be present at annual conventions by establishing new sections. The committee believed that the smaller works could benefit materially by membership in the Association but that personal intercourse between them was highly desirable and the method of developing this which seemed most feasible was to encourage the formation of sections. The portion of the report referring to appropriations for section work was referred to the Finance Committee and the remainder accepted.

The report of the representative of the American Water Works Association on the American Electrolysis Committee was read by Edward E. Minor; it is printed on page 585. The Association voted to receive the report, to continue the committee and to authorize

the Executive Committee to fill the vacancy on the committee and to take under advisement the appointment of an expert to assist the committee.

President Henderson read the following letter:

AMERICAN EXPEDITIONARY FORCES
WATER ANALYSIS LABORATORY
U. S. A. P. O. 702

Paris, May 22, 1919.

MR. CHARLES R. HENDERSON, *President*, American Water Works Association, Davenport, Iowa, U. S. A.

Dear Sir:

We are attaching a list of Sanitary Corps Officers and men who have been engaged in the Water Supply Service of the American Army in France. Some of these men are already members of the American Water Works Association and most of them will be interested in Water Supply Service as practiced in civil as well as military operations.

The tie which has bound this group of men together in Europe has been the common effort of each to do his part in supplying to the Army the best water obtainable under the conditions existing, be it from Lyster bag, water-cart, motorized purification unit, improvised front line water-point or filtration plant of a more permanent nature farther back in the Service of Supplies. They have had many common experiences in this work in France, and have made associations and hold remembrances which should be perpetuated through years to come.

The American Water Works Association has an opportunity to hold these men together in the chemical and bacteriological section and it is suggested that the American Water Works Association should extend to them an invitation to make the Association their home. The conventions of the American Water Works Association will form a common and most convenient ground for a meeting place each year.

There are also a considerable number of men in the Water Supply Branch of the Quartermaster Department which provided the water supply for the camps and cantonments of the U. S. A. who should be just as enthusiastic as we of the Sanitary Corps of the American Expeditionary Forces to perpetuate their acquaintance in an Association of Military Water Supply Officers.

Many of the members in the American Expeditionary Forces are still on duty this year, but it is hoped that they can attend the next Annual Convention.

It is suggested that a Committee be appointed to arrange for a meeting and to invite the men who appear on the attached list.

The enclosed list does not give the addresses, but, if action is taken the addresses can be obtained.

Yours truly,

EDWARD BARTON,
Lieut. Col., San. Corps.

On motion of Leonard Metcalf it was voted that a committee be appointed to arrange for a meeting of the officers and men of the Sanitary Corps engaged in the water supply service of the American Expeditionary Forces in France, of the Corps of Engineers abroad and at home, and of the water supply branch of the Quartermaster Corps and the Construction Division of the United States Army, with a view to inviting them to become members of this Association and to attend its next annual convention. Messrs. Bartow, Maury and Henderson were appointed later as the members of this committee.

In accordance with the Constitution the following candidates for the Nominating Committee were chosen: District 1, Frank A. Barbour; District 2, Lyman P. Hapgood; District 3, George C. Gensheimer and James H. Long; District 4, Henry B. Morgan and C. W. Wiles; District 5, Chester R. McFarland and F. T. Cutts; District 6, J. C. Jensen and F. W. Cappelen. The Association voted to hold the next annual convention at Montreal, P. Q.

Thursday morning, June 12, 1919. The Secretary presented a progress report from the Committee on Cold Weather Troubles, and the committee was continued. Similar action was taken on the progress report of the Committee on Revision of Standard Specification for Cast Iron Pipe and Specials, and the progress report of the Committee on Official Standards of Water Analysis.

The Secretary read a letter from the Bureau of Standards on the subject of standardization of screens and sieves, which was ordered filed. It is printed on page 572.

The report of the Committee on Standard Form of Contract was read by the Secretary and the committee was continued. The report is printed on page 583.

A paper on "The Water Distribution Systems of Industrial Housing Projects for Ship Builders" was read by W. H. C. Ramsey.

A paper on "Water Supply for the Cantonments and Other Construction Division Activities" was read by Lieut.-Col. Dabney H. Maury; it had been previously read before the American Society of Civil Engineers and was published in its *Proceedings*.

An informal talk on the methods of supplying water to the First Army, American Expeditionary Forces, while in camp and while advancing, was given by Lieut.-Col. F. W. Scheidenhelm, Corps of Engineers, who was in charge of this service and was specially authorized by the Chief of Engineers to give this address, the first

public explanation of the methods, at the Buffalo convention of the Association.

Friday morning, June 13, 1919. Major M. L. Worrell called the meeting to order and stated that in the absence of the author a paper by W. J. Orchard on "Motor-Truck-Mounted Purification Plants" would be read by title.

Capt. Harry Y. Carson presented a paper on "Some Water Supply Problems in Palestine." C. E. Abbott read a paper on "Flat Rate vs. Meters," and Capt. L. A. Fritze presented a paper on "Water Supply Service in the Army of Occupation in Germany."

Upon motion by R. L. Sackett the Association voted to place on record its appreciation of the services rendered during the war by its members who entered the army or engaged in civilian work connected with the war. The maker of the motion was given leave to elaborate its wording before it was finally put on record.

During the convention an excursion by boat was made on Lake Erie, there was a visit to Niagara Falls, an inspection of the Porter Avenue pumping station was made, and there was an informal smoker at which Major Elihu Cunnyngham Church made a brief address on the importance of taking up deferred maintenance work immediately.

The usual resolution of thanks for the courtesies offered the Association during the convention was passed upon motion of W. S. Cramer.

There were 281 active members, 211 associate members and 233 guests registered at the convention.

MINNESOTA SECTION

At a meeting of the Section held at the University of Minnesota on May 3 the following officers were elected for the ensuing year: Chairman, H. F. Blomquist; vice-chairman, D. A. Reed; trustee for three years, M. G. Holmes; D. G. Gordon and L. I. Birdsall hold over for another year as trustees. The following resolutions were adopted:

(1) The Minnesota Section of the American Water Works Association requests that a committee of the parent body be appointed to consider and submit to the American Water Works Association for adoption, standard rules for fire protection of cities of various sizes; also that this question be studied in its relation to the sanitary quality of public water supplies to the

end that these water supplies may be brought to their highest efficiency both from the standpoint of fire protection and for the protection of public health. Moreover, it is also suggested that this committee be requested to consider the question of state and federal supervision of fire protection standards.

(2) The Minnesota Section of the American Water Works Association goes on record approving the regulation of the Minnesota State Board of Health which prohibits a physical connection between water supplies which are safe and those which are unsafe from a sanitary point of view.

(3) That a committee be appointed by the chairman of the Section to devise some means of keeping the interest of the members between meetings.

The following papers were read at the meeting:

"Water Works as Fire Protection" by H. F. Blomquist; discussed by J. A. Jensen and Joseph Siebert.

"Features of Design in Small Water Works" by F. H. Bass; discussed by M. G. Holmes and W. J. Leach.

"Legal Responsibility for a Pure Water Supply" by John Wilson; discussed by F. W. Cappelen and J. C. Flanagan.

Chlorine sterilization and its accompanying difficulties were discussed by F. C. Gordon and D. A. Reed, water softening was discussed by L. I. Birdsall and J. A. Childs, and surface water pollution and its relation to water supplies were discussed by H. A. Whittaker and F. H. Bass.

The secretary, H. A. Whittaker, reports that the meeting was one of the most successful the Section has held.

IOWA SECTION

After postponing the fall meeting of 1918, on account of the influenza epidemic then prevailing, the Iowa Section considered itself fortunate in being able to arrange for a meeting in the spring of 1919, which thus became its fourth annual meeting. All of the technical sessions were held in the Hall of Physics, State University of Iowa, Iowa City. The banquet was served in the rooms of the Commercial Club, where the Section was the guest of the Club.

The meeting was opened at 10.00 a.m., April 16, with an address of welcome on behalf of the State University of Iowa, by George F. Kay, Dean of the College of Liberal Arts. W. A. Hostetler followed with an address of welcome on behalf of the Iowa City Water Company. S. L. Etnyre responded in behalf of the Iowa Section.

The following papers were presented at the morning and afternoon sessions:

"The Iron Removal Plant at Iowa State College" by C. S. Nichols.

"The Gallery Collecting System at Des Moines" by A. T. Luce.

"Cost of Water Main Construction in Mason City" by W. A. Judd.

"Substitutes for Lead in Joints" by Thomas Healey.

"Future Public Water Supplies in Iowa" by Lafayette Higgins.

Dr. Henry Albert, bacteriologist of the State Board of Health, was then called upon for a few remarks. He emphasized the close relation between the interests of the water works men of the state and the water laboratory of the State Board of Health at the State University of Iowa.

The following officers were elected: W. A. Judd, chairman; G. E. Shoemaker, vice-chairman; W. A. Hostetler, director; H. V. Knouse, director. The new officers of the section reappointed Lieut. Jack J. Hinman, Jr., now absent in A. E. F., secretary-treasurer, and J. H. Dunlap, acting secretary-treasurer.

The special committee on sanitary drinking fountains, J. H. Dunlap, chairman, presented a brief progress report and asked for continuance for another year. The request of the committee was granted. The chairman is authorized to fill the vacancy on the committee which occurred when Dr. Henry Albert found it necessary to resign.

The papers at the evening session were:

"Office Records and Accounting at Waterloo" by G. E. Shoemaker.

"Rainfall" by William Molis.

"The Standard of Purity of Water Used in Railroad Coaches" by Zelma Zentmire.

Captain M. I. Evinger was called upon for a brief description of the water works system at Camp Dodge.

On April 17, the Section assembled at 9.30 a.m. to hear the following papers:

"Laying Water Mains in Alleys" by C. R. Henderson.

"Monolithic Reinforced Concrete Lining for Water Works Reservoirs" by Homer V. Knouse.

"Cost of Emergency Pumping at Grinnell, Iowa" by W. G. Raymond.

The question of the best time for the next meeting of the Section was discussed and it seemed to be the prevailing opinion that the

next annual meeting, the fifth, should occur about October, 1919. The question of stimulating more interest in the work of the Iowa Section among the water works men of the state was presented for discussion and was referred to the Executive Committee for consideration.

In the afternoon the following papers were read and discussed:

"Water Works Improvements and Fire Insurance Rates" by Kelsey L. Walling.

"Loss of Head in Water Pipes" by S. L. Etnyre.

"Fighting the Flood of 1918 at Iowa City" by W. A. Hostetler, Superintendent, Iowa City Water Company, Iowa City.

In the afternoon an automobile excursion was enjoyed to the New Children's Hospital where the superintendent conducted the visitors through the wards. The New Armory on the West Side was then visited. Following this, the Iowa City Water Works and the flood of 1918 were studied by going to the pumping plant of the water works. The excursionists then visited the water laboratory of the State Board of Health.

It should be noted that all the expenses of the meeting such as badges, automobiles for the excursion, banquet, etc., were provided by the Commercial Club of Iowa City. The local committee in charge consisted of J. H. Dunlap, chairman; Dr. Henry Albert and W. A. Hostetler.

The total attendance was 59, including one class of 16 junior engineering students which attended part of the morning session on April 16. The average attendance of sessions was 32.

DEATHS

Joe C. Sterling, Munroe, Mich.; elected member June 24, 1903; died April, 1919.

E. W. Sluyter, Herkimer, N. Y.; elected member July 10, 1906; died April, 1919.

Allen E. Nichols, Chicago, Ill.; elected member June 8, 1916; died May 8, 1919.

Thomas N. Hooper, Davenport, Iowa; elected member April 16, 1884; died June 28, 1919.

CHANGE IN ADDRESS OF SECRETARY

After October 15 the office of the Secretary will be located in New York, in quarters rented by the Association for that purpose. The Secretary will sever his connection with the Troy Water Department before that date and did not feel that it was practicable for him to provide offices any longer for the conduct of the Society's business affairs. President Davis appointed Messrs. J. Waldo Smith, A. W. Cuddeback and the Secretary as a committee to investigate the possible accommodations for the Association's business and this committee reported in favor of renting the parlor floor of 153 West 71st Street, New York City, at the rate of $90 per month, including heat, light and telephone service. This recommendation was submitted to the letter ballot of the Executive Committee, which approved the lease of the premises by a vote of eleven to two, one member not voting. Attention is called to the fact that action had to be taken in the way of providing quarters or else adopt some radical change in the management of the Association's business, and that this action which was taken, while involving an expense of over $1,000 which was not provided for in the budget adopted at the Buffalo convention, is the only one which permits the conduct of the Association's business in the manner heretofore followed.